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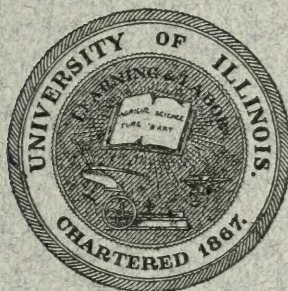
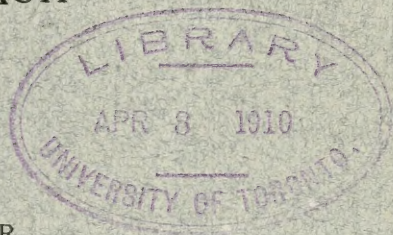
## UNIT COAL AND THE COMPOSITION OF COAL ASH

BY

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AND

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UNIVERSITY OF ILLINOIS  
ENGINEERING EXPERIMENT STATION

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UNIVERSITY OF ILLINOIS  
ENGINEERING EXPERIMENT STATION

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BULLETIN No. 37

AUGUST 1909

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UNIT COAL AND THE COMPOSITION OF COAL ASH

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AND

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I. INTRODUCTION<sup>1</sup>

It was recognized at the very outset of these experiments on coal, which were begun in the Laboratory of Industrial Chemistry, University of Illinois, about the year 1897, that much value would attach to any device or method which would make it possible to study the properties, composition, heat values, etc., of the pure coal substance as distinct from the non-coal material with which it is associated. While much data of a general nature accumulated from year to year, having more or less bearing upon this subject, it was not until recent months that a definite study of the problem was undertaken. It is the purpose of this paper to present the results of these investigations upon the properties and more definite determination of actual or unit coal. By unit coal is meant the organic material which is involved in combustion as apart from the mineral constituents which are the extraneous and variable accompaniments of the actual or unit coal.

## II. HISTORICAL REVIEW

A number of investigators have worked on various phases of this topic. Lord and Haas, who were no doubt the first in the field, have developed the idea that in any given type of coal, or perhaps, less broadly, in any given deposit of coal, there exists an initial substance, with certain uniformities as to calorific value, which might make it possible to calculate the heat units for any sample whose source as to locality was known.

From numerous analyses of Pennsylvania and Ohio coals, Lord and Haas draw a comparison between the heat values as derived by Du Long's formula, the Mahler calorimeter, and those calculated from unit value which they designate as  $H$ , and describe as being the value for the ash, water and sulphur-free substance. They find the sulphur to be a disturbing element and correct for it in a partial manner only. However, they state as their conclusion that "On comparing the results, seam by seam, it would appear

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<sup>1</sup>Credit is due Mr. W. F. Wheeler for the greater part of the work embodied in this bulletin. Mr. Wheeler died November 18, 1909.

that the actual coal of a given seam, at least over considerable areas, may be regarded as essentially of uniform heating value.”<sup>1</sup>

The expression “actual coal” presumably refers to this same initial or unit substance free from extraneous matter, such as ash, moisture and sulphur. The same idea is evidently intended in the quotation below, though the same qualification as to “actual coal” is not used, thus, “The results of our tests seem to indicate the interesting conclusion that the character of a coal seam, so far as its fuel value is concerned, is a nearly constant quantity over considerable areas. The determination of the value for seams would be of great use, as the rapid proximate analysis, or, for that matter, merely the determination of ash and moisture in low sulphur coals, would be sufficient to grade coals of the same vein. Of course, it is dangerous to argue from so few samples, but the proposition seems reasonable. At least, we hope that further work may confirm these conclusions.”

Kent, in discussing this paper, in the same volume, page 946, says, “The conclusions of the authors that the ‘actual’ coal (moisture and ash excluded) of a given seam over considerable areas, may be regarded as of uniform heating value, is one of great practical importance. I have held the same opinion tentatively for a long time....”

Contemporaneous with the work of Lord and Haas was that of W. A. Noyes.<sup>2</sup> As a result of 21 calorimetric determinations on Indiana and Pittsburgh bituminous coals, he says, “The heating effect may be found, in all cases examined, with a maximum error of 2 per cent, by the following rule: Subtract from 100 the per cents of moisture, ash, and one half the per cent of sulphur, and multiply the remainder by 80.7. The product will be the heating effect of the coal burned to vapor of water, expressed in calories.”

Whatever value may have attached to these propositions, the matter seems to have lain more or less dormant until the subject

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<sup>1</sup>Trans. Am. Inst. Min. Eng. 27; 259, 1898.

<sup>2</sup>Jour. Amer. Chem. Soc. 20; 285, 1898.



was brought again to the surface by Mr. A. Bement, who has in numerous articles insisted upon its great practical value, as, for example, referring to the advantage of having certain units of reference, he says, "The possibility of the more extended use of constants is presented and the author urges the feasibility of considering the pure coal compositions as constants for a coal seam or particular locality of such seams. This possibility has been suggested, principally by the fact that the heating power of the pure coal from a general locality does not vary over greater limits than that of the calorimetric method, and he has been able to employ it as a constant in calculating the heating power of dry and moist coal, having determined only moisture and ash, and obtained results that check with calorimetric determinations made on the same samples. The author, however, does not claim originality in this observation, but does insist that the use of such constants is of advantage. . . . This view concedes that coal from a certain locality or seam does not vary in quality, but that the variation is due to the presence of ash and moisture which are impurities associated with the coal."<sup>1</sup>

In a subsequent paper,<sup>2</sup> he argues for the same constancy of values when referred to the pure coal basis. These considerations have, no doubt, led Mr. Bement and others to adopt the term "pure coal" as expressive of this idea of constancy in the "ash and water-free" substance, in addition to the fact of its being a more compact and convenient term to use.

In all of these discussions relating to the uniformity of values for the actual coal, it is evident that if there are any constituents that fail of recognition to the extent that they are not included among the factors for mineral or non-coal material, but on the contrary, are included in the actual coal substance, then the question arises as to whether we yet have a fair basis of reference for drawing conclusions as to the constancy or the degree of agreement which we may properly credit to the actual coal constituent.

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<sup>1</sup>Jour. Am. Chem. Soc. 28; 636.

<sup>2</sup>Jour. Western Society of Engineers 11; 757.

For example, the coals of the Mississippi Valley may have as high as 4 or even 8 per cent of sulphur. Indeed, variations of 1 to 3 per cent may be possible within the product from the same mine, especially where the washing of the coal is in vogue. Now if this variable is counted as part of the "actual coal," it by so much prohibits any uniformity of heat values being credited to this hypothetical substance we call "unit coal." This phase of the subject was touched upon in the discussion<sup>1</sup> accompanying the paper by Mr. Bement already mentioned. It was there urged that not only the sulphur, but certain volatile constituents were present which escaped determination as part of the ash, and were, therefore, included in the actual coal, thus introducing a variable which prevented accurate study of that substance. Shortly afterward, analytical evidence in support of this idea was developed by Mr. Wheeler,<sup>2</sup> and the results of his investigation were published in 1908. The essential point developed in that work was the evidence of the existence of a non-coal constituent which by the ordinary methods of analysis not only escapes recognition and measurement, but is counted as part of the true coal substance. This is the water of hydration or other volatile matter chemically combined with the mineral or ash substance in such a manner as to be driven off only at a red heat. For example, if the shale content of the ash has 8 per cent combined water, and the same is not counted with the ash but as part of the "volatile combustible," here is a variable which by so far keeps us from coming at the correct value for the actual or unit coal. Similar variables would accompany the presence of gypsum whose water of crystallization in the process of analysis would take its place as part of the pure coal substance. Calcium carbonate also would afford a similar variable in so far as it would lose carbon dioxide in the process of analysis. It should be noted here that Taylor and Brinsmaid have proposed a graphical method for arriving at unit coal values which, though empirical and consequently indi-

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<sup>1</sup>Parr; Jour. Western Society of Engineers 11; p. 762, 1906.

<sup>2</sup>Trans. Am. Inst. Min. Engs., Vol. 38, p. 621, 1908.



rect in character, is very ingeniously devised and no doubt is of much practical value.<sup>1</sup>

### III. EXPERIMENTAL DATA

It is the purpose of this paper to present the results of our own investigations, together with such applications as the data at hand will permit, in the hope that the facts presented may indicate the possibility of arriving directly at the determination of all of the non-coal or mineral constituents, including those more volatile mineral compounds which have heretofore been associated in analytical processes with the fuel. The fact should be especially emphasized that it has been the purpose of the investigation to arrive, first, at an exact determination of the inorganic component of the coal as distinct from the organic material, and, second, to study the constancy of composition of this organic substance as indicated by its heat content. Only in this manner can we arrive at a conclusion as to whether or not it has properties which will warrant its use as a fuel unit. Manifestly, therefore, the sulphur should be excluded from this unit. In so far as sulphur occurs in the form of iron pyrites, and this includes the major part, it is extraneous in character and bears no constant ratio to the amount of organic matter present.

For the purpose of illustrating by specific instances the effect of including such variable constituents as sulphur, etc., in the combustible matter, instead of in the ash, and so allowing them to augment falsely the actual coal substance, the following experimental procedure was followed:

A given sample of the coal was separated into two divisions of high and low ash content in a solution of zinc sulphate of 1.35 specific gravity, whereby that part of the coal with low ash and less pyrites was separated by floating from the heavier particles with higher ash and more sulphur, the latter sinking to the bottom. Now, upon the hypothesis that the "actual coal" in these

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<sup>1</sup>Jour. Ind. and Engrg. Chem. Vol. 1, Feb. 1909.



two divisions of the same sample should have the same heat value, the subjoined table is arranged to show what widely divergent values may be indicated by reason of different methods of arriving at the "actual coal" constituent. If everything excepting the ash as weighed and the moisture be credited to this material, there will result unit values, as shown under column (a) of the subjoined Table 1, which is the "pure coal" of Mr. Bement. If we take out the heat due to sulphur, and correct the remaining value for ash as determined, plus moisture, plus all of the sulphur, there will result values as shown in column (b), which would be the results as derived by means of the method of Lord and Haas. If we calculate the indicated values to the material as free from ash and moisture and correct also for one-half of the sulphur, there will result values, as shown under column (c), which would conform to the method as suggested by Dr. Noyes.

In column (d) we have results from the method of calculation which subtracts the heat due to the sulphur, corrects the ash for the sulphur, and also adds a uniform amount for hydration or volatile inorganic matter, amounting to 8 per cent calculated upon the corrected ash free from iron pyrites, assuming all of the sulphur to be in that form. A tabular statement, therefore, for these four different methods of calculation would be as follows:

(a) According to Bement

$$\begin{array}{r} \text{B. t. u. as indicated} \\ \hline 1.00 - (\text{Moisture} + \text{Ash as weighed}) \end{array}$$

(b) According to Lord and Haas

$$\begin{array}{r} \text{B. t. u.} - 4050 \text{ S} \\ \hline 1.00 - (\text{Moisture} + \text{Ash as weighed} + \text{Sulphur}) \end{array}$$

(c) According to Noyes

$$\begin{array}{r} \text{B. t. u. as indicated} \\ \hline 1.00 - (\text{Moisture} + \text{Ash as weighed} + 1/2 \text{ Sulphur}) \end{array}$$

(d) According to Parr and Wheeler

$$\begin{array}{r} \text{B. t. u.} - 5000 \text{ S} \\ \hline 1.00 - [\text{Moisture} + \text{Ash} + 5/8 \text{ S} + .08 (\text{Ash} - 10/8 \text{ S})] \end{array}$$

TABLE 1

COMPARATIVE VALUES OF "ACTUAL COAL"

| Tab. No. | Lab. No.     | DESCRIPTION OF SAMPLE                    | OVEN-DRY COAL |      |      |          | HEAT VALUE OF "ACTUAL COAL" AS CALCULATED BY DIFFERENT METHODS       |                                                                           |                                                                              |                                                                            |
|----------|--------------|------------------------------------------|---------------|------|------|----------|----------------------------------------------------------------------|---------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------------------------------------------------------------------|
|          |              |                                          | Ash           | Sul. | Iron | B. t. u. | (a)<br>Non-coal as Ash only (uncorrected) Ref. to Indicated B. t. u. | (b)<br>Non-coal as Ash (uncorrected) + Sulphur Ref. to B. t. u. — 4050 S. | (c)<br>Non-coal as Ash + $\frac{1}{8}$ Sulphur Ref. to B. t. u. as Indicated | (d)<br>Non-coal as 1.08 $\times$ Ash + 22/40 S. Ref. to B. t. u. — 5000 S. |
| 1        | 6130<br>6131 | Sangamon Co., Ill., Lump Coal:           |               |      |      |          | Diff.                                                                | Diff.                                                                     | Diff.                                                                        | Diff.                                                                      |
|          |              | (a) Untreated.....                       | 11.66         | 5.99 | 3.38 | 12356    | 13987                                                                | 14709                                                                     | 14477                                                                        | 14331                                                                      |
|          |              | (b) Floated, Sp. Gr. less than 1.35..... | 6.12          | 3.20 | .65  | 13300    | 14164 + 177                                                          | 14523 — 186                                                               | 14412 — 65                                                                   | 14340 + 9                                                                  |
| 2        | 6122<br>6123 | Sangamon Co., Ill., Screenings:          |               |      |      |          |                                                                      |                                                                           |                                                                              |                                                                            |
|          |              | (a) Untreated.....                       | 18.21         | 4.25 | 2.37 | 11478    | 14031                                                                | 14709                                                                     | 14428                                                                        | 14442                                                                      |
|          |              | (b) Floated, Sp. Gr. Less than 1.35..... | 8.13          | 2.95 | .70  | 13043    | 14192 + 161                                                          | 14534 — 175                                                               | 14407 + 21                                                                   | 14392 — 50                                                                 |
| 3        | 6290<br>6121 | Williamson Co., Ill., Washed Nut:        |               |      |      |          |                                                                      |                                                                           |                                                                              |                                                                            |
|          |              | (a) Untreated.....                       | 12.83         | 1.85 | 1.09 | 12523    | 14361                                                                | 14593                                                                     | 14519                                                                        | 14603                                                                      |
|          |              | (b) Floated, Sp. Gr. less than 1.35..... | 4.01          | 1.39 | .54  | 13929    | 14509 + 148                                                          | 14664 + 71                                                                | 14615 + 96                                                                   | 14602 — 1                                                                  |
| 4        | 6129<br>6128 | LaSalle Co., Ill., Washed Screenings:    |               |      |      |          |                                                                      |                                                                           |                                                                              |                                                                            |
|          |              | (a) Untreated.....                       | 10.05         | 3.43 | 2.32 | 12885    | 14316                                                                | 14616                                                                     | 14602                                                                        | 14566                                                                      |
|          |              | (b) Floated, Sp. Gr. less than 1.35..... | 3.94          | 2.33 | 1.29 | 13922    | 14487 + 171                                                          | 14754 + 138                                                               | 14680 + 78                                                                   | 14615 + 49                                                                 |



TABLE 1

COMPARATIVE VALUES OF "ACTUAL COAL"—(Continued)

| Tab. Lab.<br>No. No. | DESCRIPTION OF<br>SAMPLE                    | OVEN-DRY COAL |      |             |          | HEAT VALUE OF "ACTUAL COAL" AS CALCULATED BY<br>DIFFERENT METHODS                     |                                                                                            |                                                                                            |                                                                                           |
|----------------------|---------------------------------------------|---------------|------|-------------|----------|---------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
|                      |                                             | Ash           | Sul. | Iron        | B. t. u. | (a)<br>Non-coal as<br>Ash only<br>(uncorrect-<br>ed) Ref. to<br>Indicated<br>B. t. u. | (b)<br>Non-coal as<br>Ash (uncor-<br>rected) +<br>Sulphur Ref.<br>to B. t. u. —<br>4050 S. | (c)<br>Non-coal as<br>Ash + $\frac{1}{3}$ Sul-<br>phur Ref. to<br>B. t. u.<br>as Indicated | (d)<br>Non-coal as<br>1.08 $\times$ Ash<br>+ 22/40 S.<br>Ref.<br>to B. t. u. —<br>5000 S. |
| 5                    | Vigo Co., Ind. Nut:                         |               |      |             |          |                                                                                       |                                                                                            |                                                                                            |                                                                                           |
|                      | (a) Untreated.....                          | 16.84         | 7.62 | 5.17        | 11790    | 14170                                                                                 | 15230                                                                                      | 14858                                                                                      | 14698                                                                                     |
| 6133                 | (b) Floated, Sp. Gr. less<br>than 1.35..... | 4.27          | 3.08 | 1.06        | 13870    | 14478 + 308                                                                           | 14836 — 394                                                                                | 14725 — 133                                                                                | 14638 — 60                                                                                |
| 6                    | Sullivan Co., Ind. Lump:                    |               |      |             |          |                                                                                       |                                                                                            |                                                                                            |                                                                                           |
|                      | (a) Untreated.....                          | 6.11          | 3.37 | 2.24        | 13664    | 14551                                                                                 | 14944                                                                                      | 14819                                                                                      | 14741                                                                                     |
| 6134                 | (b) Floated, Sp. Gr. less<br>than 1.35..... | 2.53          | 1.29 | .36         | 14259    | 14624 + 73                                                                            | 14771 — 173                                                                                | 14820 + 1                                                                                  | 14700 — 41                                                                                |
| 7                    | Franklin Co., Ill., Face<br>sample:         |               |      |             |          |                                                                                       |                                                                                            |                                                                                            |                                                                                           |
|                      | (a) Sp. Gr. greater than<br>1.35.....       | 18.00         | .57  | Not<br>Det. | 11639    | 14194                                                                                 | 14236                                                                                      | 14244                                                                                      | 14467                                                                                     |
| 463                  | (b) Sp. Gr. less than 1.35...               | 4.64          | .54  |             | 13765    | 14435 + 241                                                                           | 14492 + 229                                                                                | 14476 + 232                                                                                | 14513 + 46                                                                                |
| 8                    | Franklin Co., Ill., Face<br>sample:         |               |      |             |          |                                                                                       |                                                                                            |                                                                                            |                                                                                           |
|                      | (a) Sp. Gr. greater than<br>1.35.....       | 14.43         | 1.45 | "           | 12142    | 14190                                                                                 | 14495                                                                                      | 14310                                                                                      | 14433                                                                                     |
| 464                  | (b) Sp. Gr. less than 1.35...               | 3.83          | .71  | "           | 13918    | 14472 + 282                                                                           | 14550 + 60                                                                                 | 14525 + 215                                                                                | 14541 + 108                                                                               |

TABLE 1

## COMPARATIVE VALUES OF "ACTUAL COAL"—(Concluded)

|             |             | OVEN-DRY COAL                      |       |      |      | HEAT VALUE OF "ACTUAL COAL" AS CALCULATED BY<br>DIFFERENT METHODS |                                                                                |                                                                                   |                                                                                     |                                                                                    |
|-------------|-------------|------------------------------------|-------|------|------|-------------------------------------------------------------------|--------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
| Fab.<br>No. | Lab.<br>No. | DESCRIPTION OF<br>SAMPLE           | Ash   | Sul. | Iron | B. t. u.                                                          | (a)                                                                            | (b)                                                                               | (c)                                                                                 | (d)                                                                                |
|             |             |                                    |       |      |      |                                                                   | Non-coal as<br>Ash only<br>(uncorrect-<br>ed) Ref. to<br>Indicated<br>B. t. u. | Non-coal as<br>Ash (uncor-<br>rected) +<br>Sulphur Ref.<br>to B. t. u.<br>4050 S. | Non-coal as<br>Ash + $\frac{1}{2}$ Sul-<br>phur Ref. to<br>B. t. u.<br>as Indicated | Non-coal as<br>1.08 $\times$ Ash<br>+ 22/40 S.<br>Ref.<br>to B. t. u. —<br>5000 S. |
| 9           | 472<br>465  | Perry Co., Ill., Face sample:      | 22.17 | 1.15 | "    | 10922                                                             | 14033                                                                          | 14183                                                                             | 14136                                                                               | 14405                                                                              |
|             |             | (a) Sp. Gr. greater than 1.35      | 4.22  | .86  | "    | 13763                                                             | 14369 + 336                                                                    | 14464 + 281                                                                       | 14434 + 298                                                                         | 14446 + 41                                                                         |
| 10          | 537<br>466  | Perry Co., Ill., Face sample:      | 9.52  | .65  | "    | 12947                                                             | 14309                                                                          | 14384                                                                             | 14360                                                                               | 14452                                                                              |
|             |             | (a) Sp. Gr. greater than 1.35      | 2.66  | .74  | "    | 13985                                                             | 14367 + 58                                                                     | 14430 + 46                                                                        | 14422 + 62                                                                          | 14421 + 31                                                                         |
| 11          | 473<br>467  | Williamson Co., Ill., Face sample: |       |      |      |                                                                   |                                                                                |                                                                                   |                                                                                     |                                                                                    |
|             |             | (a) Sp. Gr. greater than 1.35      | 17.75 | 1.15 | "    | 11766                                                             | 14306                                                                          | 14451                                                                             | 14405                                                                               | 14509                                                                              |
|             | 467         | (b) Sp. Gr. less than 1.35         | 4.08  | .99  | "    | 13942                                                             | 14535 + 229                                                                    | 14644 + 193                                                                       | 14617 + 212                                                                         | 14615 + 16                                                                         |
| 12          | 538<br>468  | Williamson Co., Ill., Face sample: |       |      |      |                                                                   |                                                                                |                                                                                   |                                                                                     |                                                                                    |
|             |             | (a) Sp. Gr. greater than 1.35      | 18.28 | 1.37 | "    | 11731                                                             | 14355                                                                          | 14531                                                                             | 14475                                                                               | 14667                                                                              |
|             | 468         | (b) Sp. Gr. less than 1.35         | 4.34  | 1.07 | "    | 13970                                                             | 14604 + 249                                                                    | 14725 + 194                                                                       | 14694 + 219                                                                         | 14690 + 23                                                                         |



The method of deriving a formula embodying the conditions prescribed under (*d*) would be as follows:

First, with reference to the subtraction of the heat due to the sulphur. It should be borne in mind that the purposes of this study are (1), to arrive at the actual weight of unit coal as represented by the expression 1.00 — (all non-coal constituents), and (2) to derive the actual heat per unit weight to be credited to this material, by dividing the indicated heat for this substance by the weight which produces it. Hence, for this particular purpose, the sulphur must be eliminated, both as to its heat value and as to its weight in the material whose value is sought for. This procedure may not suit the purpose of the engineer who has in mind only the available heat without reference to its source, but that is a matter quite apart from the facts which it is the purpose of this discussion to establish.

Second, the expression 5000 S has been used as indicating the heat due to the combustion of the sulphur, for the reason that the value 4050 S, as used in formula (*b*) represents the heat of combustion for pure sulphur, while the heat of combustion of sulphur in the form of pyrites,  $\text{FeS}_2$ , combines also the heat of formation of iron oxide,  $\text{Fe}_2\text{O}_3$ . It is the resultant value, therefore, of the several reactions involved that is desired.

According to the direct tests by Somermeier,<sup>1</sup> in the combustion of coal with known weight of iron pyrites, the indicated heat per gram of sulphur so combined is 4957 calories. In calculating heat values, the correction introduced for the combinations resulting from calorimeter reactions as compared with open-air combustion is 2042 calories per gram of pyritic sulphur; hence 4957 — 2042 or 2915 calories (5247 B. t. u.) represents the heat due to the burning of one gram of sulphur in pyritic form instead of 2250 calories (4050 B. t. u.), the amount which would be credited to sulphur in the free condition. A strict application of these values, therefore, would call for a correction of 5247 S, as representing the heat to be subtracted for the sulphur. This,

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<sup>1</sup>Jour. Am. Chem. Soc. Vol. 26, p. 566.

however, would imply that all of the sulphur is in the pyritic form. Since a certain portion of the sulphur is always present in organic or other form of less heat-producing capacity, it is deemed more nearly correct to use an even factor of 5000 as representing the heat to be credited to unit amounts of the total sulphur present.

The factors for the divisor in the formula under (d) are derived as follows:

The atomic ratio of iron to sulphur in iron pyrites ( $\text{FeS}_2$ ) is 56 : 64; that is,  $7/8$  of the total sulphur is the equivalent of the iron present as Fe.

The atomic ratio of the oxygen of the ash, combined as  $\text{Fe}_2\text{O}_3$  to the total sulphur which it replaces is 48 : 128; that is,  $3/8$  of the total sulphur is the equivalent of the oxygen present in the ash, combined as  $\text{Fe}_2\text{O}_3$ , hence the ash as weighed may be corrected for the iron pyrites  $\text{FeS}_2$  burned to  $\text{Fe}_2\text{O}_3$ , by subtracting from the ash  $10/8$  of the weight of the sulphur as determined. This remainder, therefore, is considered as the shaley and carbonate constituent upon which the 8 per cent of water of hydration, carbon dioxide, etc., are calculated. The expression for the total non-coal substance then becomes

$$\text{Non-coal} = \text{Moisture} + \text{Ash as weighed} + 5/8 \text{ S} + .08 (\text{Ash} - 10/8 \text{ S}).$$

Clearing of fractions and combining,

$$\text{Non-coal} = \text{Moisture} + 1.08 \text{ Ash} + 21/40 \text{ S}.$$

In this expression the factor  $21/40 \text{ S}$  can not be further simplified by making it  $1/2 \text{ S}$ , for the reason that our correction for sulphur is already too small by that part of the organic sulphur not covered by the addition to the ash value of  $3/8$  of the total sulphur indicated in the original formula. On the contrary, we shall be approaching nearer the truth by increasing slightly the sulphur correction, which may be done with convenience in calculating, by making this factor read  $22/40 \text{ S}$  or  $1/2 \text{ S} + 1/20 \text{ S}$ .



Hence the simplification of the entire formula under (d) would be

B. t. u. or unit coal =

$$\frac{\text{Indicated B. t. u.} - 5000 \text{ S}}{1.00 - (\text{Moisture} + 1.08 \text{ Ash} + 1/2 \text{ S} + 1/20 \text{ S})}$$

Since the analytical values given in the table are based upon the coal as oven-dry, of course, the moisture factors in the above formula drop out, and would not enter into the calculations. In the table, for example, sample 1 has an indicated B. t. u. for the dry coal of 12 356. The calculations, therefore, for each column are

$$(a) = \frac{12356}{1.00 - .1166} = \dots\dots\dots 13\ 987$$

$$(b) = \frac{12356 - 4050 (.0599)}{1.00 - (.1166 + .0599)} = \dots\dots\dots 14\ 709$$

$$(c) = \frac{12356}{1.00 - (.1166 + .0299)} = \dots\dots\dots 14\ 477$$

$$(d) = \frac{12356 - 5000 (.0599)}{1.00 - [1.08(.1166) + .02995 + .00299]} = \dots\dots\dots 14\ 331$$

From an examination of this table it seems evident that the values in columns (a), (b), and (c) vary for each pair of samples more widely than we should expect, provided our calculation in these cases is based upon the actual coal; the variation, for example, reaching nearly 2 1/2 per cent in No. 9. That a hydration component is the disturbing factor seems evident from the wide variation in the ash of the two divisions of this sample (22.17 per cent to 4.22 per cent), while the sulphur values are sufficiently close to eliminate any variable due to that element. In column (d), however, it is to be noted that the introduction of an amount of hydration equal to 8 per cent of the pyrite-free ash brings the two heat values to a variation of only 41 B. t. u. or less than 1/3 of 1 per cent. The component calling for this correction, therefore, seems to be directly associated with the ash, since the variation

in sulphur is too small to enter into the account. Equally striking evidence of the presence of such a component is seen in the samples numbered 7, 10, 11, and 12. Sample 8 is essentially the same as 7, and while there is not so close an agreement in this sample, still it must be recognized as confirmatory of the general proposition. If, for example, we admit a manipulation variant of 40 or 50 units, it is hardly to be expected that the other variables, such as the true amount of hydration or the exact character of the same, whether hydration of shale or carbonating of lime, may not carry with it an equal variable, so that in the present stage of our knowledge, it seems fair to consider even this variation quite within reasonable limits.

Another phase of these results is also to be noted. The agreement as to results just given above is seen to depend in large measure upon the correction of the high ashes in those samples referred to, by addition of a component which we have designated as hydration. Fortunately, the list of samples also includes coals high in sulphur, and this affords the necessary condition to show whether or not the sulphur enters into the proposition as a variable, and also what method of correction will most nearly neutralize its effect. Here, again, the close agreement, as in samples 1, 2, 4, 5, and 6, indicates that the method employed is correct in principle; that is, the heat value of the sulphur, taken as 5000 times the sulphur content, is subtracted from the indicated heat units, and the ash is restored as nearly as is conveniently possible, to include the sulphur as joined to the iron in its original or pyritic form. It is realized, as already indicated, that an error is inherent in this procedure, if that part of the sulphur is present as organically combined. Strictly considered, therefore, it should not be reckoned as pyritic sulphur. Test has been made, however, of introducing a further refinement into the calculation by separating the sulphur into the organic part and the inorganic, the amount of the latter being indicated by the content of iron present in the ash. The iron pyrites thus calculated, Table 2, on this iron basis has been



made a part of the original non-coal substance. The 8 per cent of hydration, etc., has then been calculated to the ash as corrected for this amount of pyrites burned to oxide, and finally the organic sulphur has been added as a part of the non-coal matter. The indicated heat units were diminished by the total heat to be credited to the sulphur, taking account of its two forms as indicated in the formula for column (e), thus

(e) =

$$\frac{\text{B. t. u.} - [5247 \times 8/7 \text{ Fe} + 4050 \times (\text{S} - 8/7 \text{ Fe})]}{1.00 - [\text{Moisture} + \text{Ash} + 5/7 \text{ Fe} + .08 (\text{Ash} - 10/7 \text{ Fe}) + (\text{S} - 7/8 \text{ Fe})]}$$

In this formula, the iron weighed as  $\text{Fe}_2\text{O}_3$  has a ratio of oxygen to iron of 48 : 112 or 3/7. To restore it to an equivalent of  $\text{FeS}_2$  which has a ratio of S (64) to Fe (56) or 8 : 7 would require the addition to the ash content of 5/7 of the iron as determined. Similarly 8/7 of the iron value represents the sulphur as originally joined to the iron in the pyritic form, and 10/7 of the iron represents the  $\text{Fe}_2\text{O}_3$  as a component part of the ash as weighed.

Since the analytical values refer to the coal on the dry basis, the factor for moisture drops out of the formula. The results of this method of calculating are given for the first six samples in column (e) of Table 2, placed in comparison with column (d) repeated from the previous table. As may be readily seen, the relative values are in substantially the same agreement as before. This method involves the added requirement of an iron determination and does not altogether remove the uncertainty as to the form in which the combinations of sulphur occur. In the present state of our knowledge, as well as on the score of practicability, we seem to be justified in accepting the values and formula as given in column (d).

The arguments thus far brought forward to prove the correctness of the method for arriving at the real weight of non-coal substance are sufficiently conclusive for the twelve samples included in the table. How generally applicable this method will be for all types and all regions, remains for the subsequent part of this paper to discuss.

TABLE 2

## COMPARATIVE VALUES OF "ACTUAL COAL"

| Tab.<br>No. | Lab.<br>No. | DESCRIPTION OF SAMPLE                                                                         | OVEN-DRY COAL |              |      |          | (d)                          | (e)                                                                                                                                                                                                             |
|-------------|-------------|-----------------------------------------------------------------------------------------------|---------------|--------------|------|----------|------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|             |             |                                                                                               | Ash           | Sul-<br>phur | Iron | B. t. u. |                              |                                                                                                                                                                                                                 |
| 1           | 6130        | Sangamon Co., Ill., Lump Coal:<br>(a) Untreated<br>(b) Floated, Sp. Gr. less than 1.35        | 11.66         | 5.99         | 3.38 | 12356    | Diff.<br>14331<br>14340 + 9  | Non-coal as 1.08<br>Ash + 22/40 S.<br>Ref. to B. t. u.<br>— 5000S.<br>Non-coal as Ash,<br>Water, Pyritic<br>Sulphur, Organic<br>Sulphur and 8%<br>Ash as Corrected<br>for Actual Fe <sub>2</sub> O <sub>3</sub> |
| 2           | 6131        |                                                                                               | 6.12          | 3.20         | .65  | 13300    |                              |                                                                                                                                                                                                                 |
| 3           | 6122        | Sangamon Co., Ill., Screenings:<br>(a) Untreated<br>(b) Floated, Sp. Gr. less than 1.35       | 18.21         | 4.25         | 2.37 | 11478    | Diff.<br>14442<br>14392 — 50 | 14569<br>14567 — 2                                                                                                                                                                                              |
| 4           | 6123        |                                                                                               | 8.13          | 2.95         | .70  | 13043    |                              |                                                                                                                                                                                                                 |
| 5           | 6200        | Williamson Co., Ill., Washed Nut:<br>(a) Untreated<br>(b) Floated, Sp. Gr. less than 1.35     | 12.83         | 1.85         | 1.09 | 12523    | Diff.<br>14603<br>14602 — 1  | 14605<br>14659 + 54                                                                                                                                                                                             |
| 6           | 6121        |                                                                                               | 4.01          | 1.39         | .54  | 13929    |                              |                                                                                                                                                                                                                 |
| 7           | 6129        | LaSalle Co., Ill., Washed Screenings:<br>(a) Untreated<br>(b) Floated, Sp. Gr. less than 1.35 | 10.05         | 3.43         | 2.32 | 12885    | Diff.<br>14566<br>14615 + 49 | 14620<br>14680 + 60                                                                                                                                                                                             |
| 8           | 6128        |                                                                                               | 3.94          | 2.33         | 1.29 | 13922    |                              |                                                                                                                                                                                                                 |
| 9           | 6132        | Vigo Co., Ind., Nut:<br>(a) Untreated<br>(b) Floated, Sp. Gr. less than 1.35                  | 16.84         | 7.62         | 5.17 | 11790    | Diff.<br>14698<br>14638 — 60 | 14779<br>14783 + 4                                                                                                                                                                                              |
| 10          | 6133        |                                                                                               | 4.27          | 3.08         | 1.06 | 13870    |                              |                                                                                                                                                                                                                 |
| 11          | 6135        | Sullivan Co., Ind., Lump:<br>(a) Untreated<br>(b) Floated, Sp. Gr. less than 1.35             | 6.11          | 3.37         | 2.24 | 13664    | Diff.<br>14741<br>14700 — 41 | 14833<br>14770 — 63                                                                                                                                                                                             |
| 12          | 6134        |                                                                                               | 2.53          | 1.29         | .36  | 14259    |                              |                                                                                                                                                                                                                 |



As a possible source of variation, the different layers of the same seam were studied with a view to determining inherent variations in the stratification of the coal, which, by variations in sampling or mining, might enter into the case and to a certain extent, modify the fact of uniformity. Three mines were, therefore, sampled with reference to the top, middle, and bottom layers of coal, or with reference to certain zones or bands of coal that seemed to have a structure more or less characteristic and distinct from the other layers. These results are listed in the following table, the basis of comparison being the thermal units calculated to "unit coal," which in subsequent discussion, as already indicated, will be the term made use of in this paper for that coal free from ash, moisture, pyrites, and volatile inorganic matter, as calculated under column (*d*) in Tables 1 and 2.

Attention is called to the following points. In the Collinsville sample, the bands of division were approximately the upper 2 feet, the lower 2 feet, and the middle zone of about 4 feet. When referred to the "unit coal" basis, the upper and middle divisions are in close agreement. The lower layer is considerably higher. This fact would have a modifying influence on the entire face of the seam as is illustrated in No. 4, which is a calculated composite value based on the factors for samples No. 1, 2 and 3. No. 5 and 6 are samples taken from the entire face of the seam, and taken from a mine located not over 2 or 3 miles from the mine from which the first samples by layers were taken. It is evident that the values indicated for the separate layers are not variable to an extent which would noticeably change the ultimate value for the entire face. Moreover, in the process of mining, the output represents the face of the vein and not the various layers. However, the facts brought out in this comparison of the various strata are valuable as indicating certain variations in composition of the same seam which might result from changes in the relative thickness of certain bands. In the same region, or in the same vein, these possible variations due to this phase of the matter would seem to be practically negligible when we consider

the regular output of the mine, since a mixture of the entire seam is inevitable, and these small variations of the layers would be very easily neutralized.

The same statement is applicable to the results as shown for the two additional sections similarly examined from Belleville

TABLE 3

VARIATIONS IN THE CALORIFIC VALUE OF THE "UNIT COAL" FOR DIFFERENT HORIZONTAL LAYERS OF THE SEAM

| Tab. No. | Lab. No. | DESCRIPTION OF SAMPLE                      | OVEN-DRY COAL |          |          | Non-coal as 1.08 Ash + 22/40 S. Ref. to B. t. u. — 5000S. |
|----------|----------|--------------------------------------------|---------------|----------|----------|-----------------------------------------------------------|
|          |          |                                            | Ash           | Sul-phur | B. t. u. |                                                           |
|          |          | COLLINSVILLE, ILLINOIS                     |               |          |          |                                                           |
| 1        | 725c     | Top 23 in.....                             | 6.14          | 4.44     | 13505    | 14606                                                     |
| 2        | 725b     | Middle 48 in.....                          | 12.02         | 3.84     | 12618    | 14634                                                     |
| 3        | 725a     | Bottom 22 in.....                          | 14.86         | 7.52     | 12297    | 14936                                                     |
| 4        | 725      | Calculated for entire face 93 in.....      | 11.22         | 4.85     | 12762    | 14694                                                     |
| 5        | 723      | Sample taken from entire face.             | 12.23         | 4.37     | 12604    | 14675                                                     |
| 6        | 724      | Sample taken from entire face.             | 9.69          | 3.33     | 12982    | 14613                                                     |
|          |          | BELLEVILLE, ILLINOIS                       |               |          |          |                                                           |
| 1        | 1000     | Top 4 in.....                              | 6.75          | 3.35     | 13629    | 14814                                                     |
| 2        | 999      | $\frac{1}{2}$ in.; 2 in. from the top..... | 2.09          | 2.66     | 14255    | 14667                                                     |
| 3        | 995      | Entire face, 76- $\frac{1}{2}$ in.....     | 12.47         | 4.19     | 12587    | 14694                                                     |
|          |          | DUQUOIN, ILLINOIS                          |               |          |          |                                                           |
| 1        | 422      | Top 30 in.....                             | 6.13          | .76      | 13573    | 14560                                                     |
| 2        | 421      | Bottom 69 in.....                          | 14.71         | .98      | 12181    | 14516                                                     |
| 3        | ....     | Entire face. 99 in.....                    | 12.11         | .91      | 12603    | 14531                                                     |

and Duquoin. The agreement is even more marked than in the case of the Collinsville seam.

Notwithstanding these evidences of uniformity, the fact should not be lost sight of that these results have a special value in that they show at a glance the necessity of care in taking face samples, to see that the cut is made equally and from the entire working face of the seam. It is evident also that lump or hand samples which are frequently taken for analysis are not only of

little value but are as a rule positively misleading, and the error is quite as likely to be of a minus as of a plus character.

#### IV. ASH COMPOSITION

Notwithstanding the very satisfactory indication of the adaptability of the proposed formula for arriving at the unit coal values, as shown by the foregoing Tables 1 and 2, the question still remains as to whether the samples chosen are sufficiently typical to represent all the varieties of composition so far as the ash or inorganic content is concerned. Under this division of the subject, therefore, is taken up a study of this phase of the matter. As a first step, it was deemed necessary to make an analysis of the ash of the coals selected for use in the above tables. For example, the somewhat arbitrary factor, 8 per cent, has been adopted as covering a constant amount of volatile inorganic constituent to be reckoned with the total ash. It may make an appreciable difference whether this component is present as water of hydration, as in a clay or shale, or combined with lime as carbon dioxide. If in the latter combination, the amount of lime present would be an indication of that fact, while the amount of alumina present might serve to indicate the likelihood of this percentage being represented by hydration of shale or clay. An analysis of the ash of the 12 samples as listed in Table 2 is given in Table 4.

In this table, attention is first called to the fact that, with the exception of sample 3, the amount of lime is quite uniform. Here the lime approximates 12 per cent. By reference to the column for alumina, which might be taken as an indication of the clayey matter present, a very fair uniformity also exists, with the possible exception of sample 11, where the aluminium content is relatively low. Now, turning to Table 2 for an indication of a variation in the calculated values for unit coal, it does not seem that these variations in samples No. 3 and No. 11 have entered into the case in an appreciable degree.

Thus far it might be safe to conclude, that the adoption of



the 8 per cent constant, as representing the volatile matter of the ash, is applicable. However, if in this group we have a variation in the lime content from 2 to 12 per cent, as in samples 7 and 3, have we any evidence that it stops there? Similarly,

TABLE 4  
ASH COMPOSITION OF COALS OF TABLE 2

| Tab. No. | Lab. No. | DESCRIPTION                                | Ash in Dry Coal % | ANALYSIS OF ASH Per Cent |                                |                                |       |       |
|----------|----------|--------------------------------------------|-------------------|--------------------------|--------------------------------|--------------------------------|-------|-------|
|          |          |                                            |                   | SiO <sub>2</sub>         | Fe <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | CaO   | MgO   |
| 1        | 6130     | Sangamon Co., Ill., Lump.                  | 11.66             | 33.1                     | 42.5                           | 17.9                           | 5.6   | 0.9   |
| 2        | 6131     | Sangamon Co., Ill., Lump.                  | 6.12              | 54.2                     | 16.4                           | 24.2                           | 4.1   | 1.2   |
| 3        | 6122     | Sangamon Co., Ill., Screenings.....        | 18.21             | 49.2                     | 20.7                           | 17.1                           | 11.9  | 1.1   |
| 4        | 6123     | Sangamon Co., Ill., Screenings.....        | 8.13              | 55.9                     | 13.0                           | 23.6                           | 6.7   | 0.8   |
| 5        | 6290     | Williamson Co., Ill., Washed Nut.....      | 12.83             | 54.1                     | 12.1                           | 23.8                           | 6.7   | 1.2   |
| 6        | 6121     | Williamson Co., Ill., Washed Nut.....      | 4.01              | 51.7                     | 19.3                           | 24.6                           | 2.4   | 1.0   |
| 7        | 6129     | La Salle Co., Ill., Washed Screenings..... | 10.05             | 40.3                     | 34.0                           | 22.8                           | 2.0   | 0.9   |
| 8        | 6128     | La Salle Co., Ill., Washed Screenings..... | 3.94              | .....                    | .....                          | .....                          | ..... | ..... |
| 9        | 6132     | Vigo Co., Ind., Nut.....                   | 16.84             | 32.9                     | 43.8                           | 20.5                           | 2.9   | 0.9   |
| 10       | 6133     | Vigo Co., Ind., Nut.....                   | 4.27              | 35.1                     | 35.6                           | 25.3                           | 2.3   | 0.6   |
| 11       | 6135     | Sullivan Co., Ind., Lump..                 | 6.11              | 27.1                     | 52.3                           | 14.1                           | 4.4   | 1.2   |
| 12       | 6134     | Sullivan Co., Ind., Lump..                 | 2.53              | 45.8                     | 20.2                           | 28.3                           | 5.4   | 0.0   |

if the alumina may drop from 25 per cent (No. 10) to 14 per cent (No. 11), can we conclude that these numbers represent the limits of variation, and, if not, will greater variations in these factors cause a disturbance in the factor chosen to represent the volatile matter present?

In extending our study over a wider range of ash analysis, we soon come upon cases where much higher percentages of lime are in evidence. In view of this fact, it was considered worth while to estimate also the carbon dioxide and the chlorine. The carbon dioxide would be a more direct index of volatile loss of ash than the content of lime, since the latter might be combined in other than carbonate form. Chlorine, if present in any form,

would be volatile, depending on the temperature made use of. Table 5 is given as illustrating the extremes to which lime as calcium carbonate, and alumina combined as clayey matter may be met, at least in the ash from Illinois coals.

TABLE 5  
ASH COMPOSITION OF COALS WITH HIGH PERCENTAGE OF LIME

| Tab. No. | Lab. No. | DESCRIPTION           | In per cent of Dry Coal |                 |      | ANALYSIS OF ASH  |                                |                                |      |     |
|----------|----------|-----------------------|-------------------------|-----------------|------|------------------|--------------------------------|--------------------------------|------|-----|
|          |          |                       | Ash                     | CO <sub>2</sub> | Cl   | SiO <sub>2</sub> | Fe <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | CaO  | MgO |
| 1        | 734      | Grundy Co., Ill.....  | 5.82                    | .88             | none | 22.8             | 32.4                           | 10.2                           | 34.0 | 0.7 |
| 2        | 1095     | Saline Co., Ill.      | 11.49                   | 1.22            | .04  | 32.7             | 33.0                           | 9.0                            | 25.3 | 0.8 |
| 3        | 1178     | Clinton Co., Ill..... | 15.56                   | 2.48            | .10  | 39.0             | 22.4                           | 6.3                            | 31.7 | 0.7 |
| 4        | 1403     | Peoria Co., Ill.....  | 15.46                   | 2.48            | none | 25.7             | 12.9                           | 6.8                            | 54.5 | 1.5 |

It might be argued from the results in Table 5, that whereas the lime content is high, the alumina is low, and there is, therefore, a compensation which would still furnish evidence that the 8 per cent constant for the inorganic volatile matter would be applicable. However, to test the matter, it was deemed advisable to subject these samples to the floating test as already indicated, giving as a result two divisions of each sample, one with an abnormally low ash, the other with an abnormally high ash; the latter division in each case still further accentuating the lime factor. In consequence of this division, the analysis of the eight resulting samples together with the calorific values is presented in Table 6. Columns (a) and (d) only are given in order that a comparison may be made between the ash values for "ash and water-free" or "pure coal" with the "unit coal" values as derived by the formula already made use of on page 14.

From the calculations under column (a) and column (d), it is evident that the wide discrepancies under column (a) are due to a failure to take into consideration those mineral constit-

units of the coal which properly belong to the ash. This is the fuel unit designated the "ash and water-free," combustible or "pure coal" basis adopted by engineers. Under column (*d*), the

TABLE 6

PROXIMATE ANALYSIS WITH CALORIFIC VALUES FOR FLOAT AND SINK COAL WITH HIGH PERCENTAGES OF LIME IN THE ASH

| Tab. No. | Lab. No. | DESCRIPTION        | In per cent of Dry Coal |      |          | Heat Value of "Actual Coal" as Calculated by Different Methods |                                                                |
|----------|----------|--------------------|-------------------------|------|----------|----------------------------------------------------------------|----------------------------------------------------------------|
|          |          |                    | Ash                     | Sul. | B. t. u. | (a)                                                            | (d)                                                            |
|          |          |                    |                         |      |          | "Pure Coal" Basis                                              | "Unit Coal" Basis                                              |
|          |          |                    |                         |      |          | B. t. u.<br>1.00 — Ash                                         | B. t. u. — 5000S.<br>1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |
|          |          |                    |                         |      |          | Diff.                                                          | Diff.                                                          |
| 1        | 734      | Float, Grundy Co.  | 4.57                    | 1.44 | 13475    | 14120                                                          | 14217                                                          |
| 2        | 734      | Sink, Grundy Co.   | 21.99                   | 5.00 | 10733    | 13760                                                          | 14262                                                          |
|          |          |                    |                         |      |          | - 360                                                          | + 45                                                           |
| 3        | 1095     | Float, Saline Co.  | 6.42                    | 2.65 | 13663    | 14600                                                          | 14768                                                          |
| 4        | 1095     | Sink, Saline Co.   | 19.94                   | 7.01 | 11122    | 13902                                                          | 14906                                                          |
|          |          |                    |                         |      |          | - 698                                                          | + 138                                                          |
| 5        | 1178     | Float, Clinton Co. | 8.54                    | 1.96 | 12634    | 13813                                                          | 13975                                                          |
| 6        | 1178     | Sink, Clinton Co.  | 31.90                   | 3.75 | 8856     | 13004                                                          | 13654                                                          |
|          |          |                    |                         |      |          | - 809                                                          | - 321                                                          |
| 7        | 1403     | Float, Peoria Co.  | 10.37                   | 2.39 | 12796    | 14276                                                          | 14489                                                          |
| 8        | 1403     | Sink, Peoria Co.   | 34.24                   | 4.71 | 9216     | 14014                                                          | 14859                                                          |
|          |          |                    |                         |      |          | - 262                                                          | + 370                                                          |

unit coal values come very much closer together, but are not in such satisfactory agreement as was the case with the coals in Table 2, having a low lime content in the ash. It is evident, therefore, that in these two extreme divisions which have been made by the process of floating out to get the lighter and sinking the heavier ash coal, the inorganic volatile matter must be accounted for in some further correction than would be included in the 8 per cent adopted in calculation for Table 2. It is evident in this set of samples, that we have accentuated in an extreme manner the effect of a high ratio of carbonate of lime, bringing this constituent up to 16.67 per cent of the total coal in No. 5 of



the table, and to 11.99 per cent in No. 6. While these percentages are abnormal, they serve well the purpose of indicating the effect upon the proposed formula for arriving at unit coal values. The first question which presents itself, therefore, is whether we should not correct our ash factor, not by an 8 per cent addition alone, but by adding directly to the ash as weighed, the amount of carbon dioxide present, on the assumption that all of the calcium carbonate would be decomposed, setting free the  $\text{CO}_2$ . This involves another hypothesis, namely, that in the ordinary determination of ash, the calcium carbonate present is completely decomposed. To test this point, the four samples, subdivided into pairs of low and high ash each, were subjected first to the ordinary ash determination as directed by the Committee of the American Chemical Society on standard methods for coal analysis. No important modification of this method was employed. After complete burning off of the carbon in a porcelain crucible over a Bunsen lamp, a blast lamp, driven at moderate intensity, was applied for 30 to 40 minutes. The results are listed in Table 7, in the first column for ash percentages, marked (*a*). In the column marked (*b*), the method employed made use of a platinum crucible and after burning off the carbon, an intense heat was applied by means of the blast lamp, continuing the blasting to constant weight. As will be seen from these results, a very wide difference may be made in the seemingly simple matter of determining the ash. Evidently under column (*a*) only a part of the calcium carbonate has been decomposed in the "sink" samples.

In this table, therefore, we have a striking illustration of the variations that may enter into the ash determination. The evidence of a variable element indicated its presence in a very marked manner in the process of obtaining the values for column (*a*). It was found almost impossible to secure duplicate results, the values sometimes varying in the two portions run in parallel by as much as 1.00 per cent. This evidence of a high content of calcium carbonate and its effect on the accuracy of the ash deter-

TABLE 7

VARIATIONS IN ASH VALUES WHERE CALCIUM CARBONATE IS A CONSTITUENT OF THE COAL

| Tab. No. | Lab. No. | DESCRIPTION                | (b)                                      |                                                           | Difference in per cent of Dry Coal |
|----------|----------|----------------------------|------------------------------------------|-----------------------------------------------------------|------------------------------------|
|          |          |                            | (a)<br>Ash as Determined by Usual Method | Ash as Determined by Blasting to Constant Wght and Fusion |                                    |
| 1        | 734      | Float, Grundy Co., Ill.    | 4.57                                     | 3.54                                                      | 1.03                               |
| 2        | 734      | Sink, Grundy Co., Ill...   | 21.99                                    | 16.85                                                     | 5.14                               |
| 3        | 1095     | Float, Saline Co., Ill...  | 6.42                                     | 5.96                                                      | 0.46                               |
| 4        | 1095     | Sink, Saline Co., Ill....  | 19.94                                    | 18.59                                                     | 1.35                               |
| 5        | 1178     | Float, Clinton Co., Ill... | 8.54                                     | 7.23                                                      | 1.31                               |
| 6        | 1178     | Sink, Clinton Co., Ill...  | 31.90                                    | 26.88                                                     | 5.02                               |
| 7        | 1403     | Float, Peoria Co., Ill...  | 10.37                                    | 9.08                                                      | 1.29                               |
| 8        | 1403     | Sink, Peoria Co., Ill....  | 34.24                                    | 22.93                                                     | 11.31                              |

mination is of far-reaching importance. It affects in a very material manner any method of reference to a unit of combustible, especially such as is made use of by the engineering profession under the designation of "ash and moisture-free" material. It also seriously affects those results in a coal analysis which are obtained indirectly by difference. For example, the value for fixed carbon is thus estimated. Any error in the ash determination is therefore loaded upon this constituent. An equally erroneous feature accompanies the ultimate analysis where the total carbon is measured as  $\text{CO}_2$ . The carbon dioxide combined with the calcium oxide in the coal is thus made to appear in the final result as augmenting the value for total carbon. But it is not the purpose here to discuss the effect of this possible source of error. The immediate problem in hand is to arrive at the actual non-coal or inorganic substance as an essential factor in calculating the values for unit coal. The obvious suggestion, therefore, would be to make a determination of all possible volatile constituents, especially the  $\text{CO}_2$  and  $\text{Cl}$  and augment the ash values found at the higher temperature by these percentages. Such an analysis was made, as shown in Table 8. A complete

analysis was also made showing all the mineral constituents, so that any bearing these factors might have, could be studied simultaneously with the question of the true ash or inorganic matter.

In considering the probable reactions of the ash at a fusion temperature, it would be conceded at once that all of the  $\text{CO}_2$  would be driven off. This, therefore, would be the first increment to add to the ash as above determined. Similarly, the chlorine present would be driven off. Evidently, in these particular samples, the larger portion of the chlorine is combined as  $\text{CaCl}_2$ , which was not washed out of the texture of the coal after being subjected to the floating process in a  $\text{CaCl}_2$  solution. But whether joined as  $\text{NaCl}$  or  $\text{CaCl}_2$ , it is probable that the ultimate result is the formation of silicates of sodium and calcium with liberation of chlorine. Hence it seems proper to add a second increment to the ash values, that of the chlorine percentages. When we come to a disposition of the  $\text{SO}_3$  value, the case is not so clear. Ordinarily, it should be noted, the amount of sulphate present in a coal is so small as to be negligible, but it so happens that the samples selected for this particular series had been in laboratory storage for over a year, with the result, that when the ultimate constituents were all sought out, quite an appreciable amount of sulphate of iron had formed. Now the decomposition of this material is easily effected at a temperature above  $300^\circ$ . Hence the indication would seem to be that a further correction for the ash content should be made by adding the percentage found for this constituent. However, it should be borne in mind that calcium carbonate is present in sufficient quantity to take care of this  $\text{SO}_3$  by formation of  $\text{CaSO}_4 + \text{CO}_2$ . By testing artificial mixtures of calcium carbonate and ferrous sulphate, with and without the addition of organic matter, the residual fusion showed sufficient sulphate remaining as  $\text{CaSO}_4$  to warrant the conclusion that no correction should be made for the  $\text{SO}_3$  found to be present in the original coal.

In view of these facts, therefore, the calculation for the unit



TABLE 8—Ash Composition—IN PER CENT OF DRY COAL

| Tab. No. | Lab. No. | Description | Ash by Blasting to Constant Weight and Fusion in Pt. Cruc. | SiO <sub>2</sub> | Fe <sub>2</sub> O <sub>3</sub><br>Al <sub>2</sub> O <sub>3</sub> | CaO<br>MgO | Na  | Cl   | SO <sub>3</sub> | CO <sub>2</sub> | Total S | B. t. u. |
|----------|----------|-------------|------------------------------------------------------------|------------------|------------------------------------------------------------------|------------|-----|------|-----------------|-----------------|---------|----------|
| 1        | 734      | Float.....  | 3.54                                                       | .98              | 1.71                                                             | .85        | .12 | 1.00 | .43             | .10             | 1.44    | 13475    |
| 2        | 734      | Sink.....   | 16.85                                                      | 2.44             | 7.91                                                             | 6.50       | .31 | 1.15 | 1.05            | 3.68            | 5.00    | 10733    |
| 3        | 1095     | Float.....  | 5.96                                                       | 2.93             | 2.63                                                             | .40        | .07 | .17  | .22             | .13             | 2.65    | 13663    |
| 4        | 1095     | Sink.....   | 18.59                                                      | 5.23             | 9.48                                                             | 3.88       | .23 | .31  | .81             | 2.38            | 7.01    | 11122    |
| 5        | 1178     | Float.....  | 7.23                                                       | 3.33             | 3.02                                                             | .88        | .23 | 1.41 | .20             | .21             | 1.96    | 12634    |
| 6        | 1178     | Sink.....   | 26.88                                                      | 9.03             | 9.49                                                             | 8.36       | .27 | 1.20 | .56             | 5.27            | 3.75    | 8856     |
| 7        | 1403     | Float.....  | 9.08                                                       | 5.46             | 2.33                                                             | 1.29       | .22 | 1.07 | .23             | .31             | 2.39    | 12796    |
| 8        | 1403     | Sink.....   | 22.93                                                      | 5.64             | 7.09                                                             | 10.20      | .19 | 1.17 | .99             | 7.35            | 4.71    | 9216     |

TABLE 9—"UNIT COAL" IN SAMPLES WITH HIGH CALCIUM CARBONATE

| Tab. No. | Lab. No. | Description | IN PER CENT OF DRY COAL                             |                 |      |          |                | "PURE COAL"      |                                                              | "UNIT COAL" |  |
|----------|----------|-------------|-----------------------------------------------------|-----------------|------|----------|----------------|------------------|--------------------------------------------------------------|-------------|--|
|          |          |             | Ash as Determined by High Fusion to Constant Weight | CO <sub>2</sub> | Cl   | B. t. u. | B. t. u. — Ash | B. t. u. — 5000S | 1.00 — (1.08 Ash (corr.) + <sup>27</sup> / <sub>40</sub> S.) |             |  |
| 1        | 734      | Float.....  | 3.54                                                | 10              | 1.00 | 13475    | 13969          | 14219            | Diff.                                                        |             |  |
| 2        | 734      | Sink.....   | 16.85                                               | 3.68            | 1.15 | 10733    | 12908          | 14214            | — 5                                                          |             |  |
| 3        | 1095     | Float.....  | 5.96                                                | .13             | .17  | 13663    | 14528          | 14742            | — 6                                                          |             |  |
| 4        | 1095     | Sink.....   | 18.59                                               | 2.38            | .31  | 11122    | 13662          | 14736            | — 6                                                          |             |  |
| 5        | 1178     | Float.....  | 7.23                                                | .21             | 1.41 | 12634    | 13618          | 14030            | — 21                                                         |             |  |
| 6        | 1178     | Sink.....   | 26.88                                               | 5.27            | 1.20 | 8856     | 12111          | 14009            | — 21                                                         |             |  |
| 7        | 1403     | Float.....  | 9.08                                                | 3.37            | 1.07 | 12796    | 14073          | 14508            | — 336                                                        |             |  |
| 8        | 1403     | Sink.....   | 22.93                                               | 7.35            | 1.17 | 9216     | 11941          | 14172            | — 336                                                        |             |  |

coal values on these samples was based on an ash content in which the ash as weighed had been subjected to a very high temperature in a platinum crucible, and continued until a constant weight was secured, and the ash fused; to this was added the  $\text{CO}_2$  present in the dry coal, and also the factor for chlorine. The formula already given, therefore, was simply modified by the above conditions, and would be expressed as follows:

$$\text{Unit Coal} = \frac{\text{Indicated B. t. u.} - 5000 \text{ S}}{1.00 - [(\text{Ash} + \text{CO}_2 + \text{Cl}) \times 1.08 + 22/40 \text{ S}]}$$

The results of this calculation are given in Table 9, with a comparison wherein the values are calculated to "pure coal" or the "ash and water-free" basis and to the "unit coal" with the ash corrected for the  $\text{CO}_2$  and Cl present.

Concerning these results, the proposed correction of the ash by addition of the  $\text{CO}_2$  and Cl would seem to meet the conditions as indicated by the close agreement of the "unit coal" values. The last sample, No. 8 of the table, is not in so good agreement as could be wished. The only explanation to be suggested at the present time is that the very high per cent of calcium carbonate, 16.67 per cent, would seem to require that a correction be made in the calorimetric value to allow for the heat of decomposition required to separate that amount of calcium carbonate into its constituent parts. This would mean that  $786.6 \times 16.67$  per cent or 131 B. t. u. would represent the heat of dissociation for the calcium carbonate present. This amount, added to the indicated heat, would represent the total heat developed in the combustion as 9112 B. t. u. This amount introduced into the formula would show 14 383 B. t. u. as the unit coal value, or a difference from the low ash sample of 112 units instead of 336 as in the table. More study of this extreme type of coal must be made, and upon fresh samples with the sulphate constituent eliminated, before a final judgment can be formulated as to the adaptability of the formula to such cases. The remarkable conformity of the values in three of the four cases would seem to

argue strongly in favor of the corrections for  $\text{CO}_2$  and Cl as covering the case. In consideration of the facts set forth, therefore, in these last tables, it was deemed necessary to make an extended inspection of the coals of the State with special reference to their content of carbonate and chlorine. About sixty samples were selected and in addition to the usual ash determination, analysis

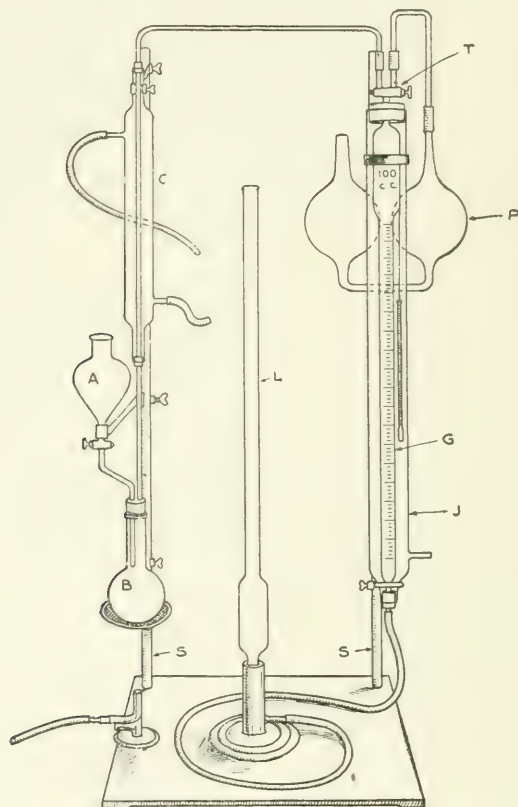


FIG. 1 APPARATUS FOR DETERMINING  $\text{CO}_2$

was made of the ash constituent, namely, silicon, iron, alumina, lime, and magnesia. In addition, a determination was made of the chlorine and carbonate present. The chlorine was determined by digesting 2 grams of the pulverized coal on a steam



bath with about 200 cc. of water, filtering, making up to 500 cc., and titrating an aliquot part with standard silver nitrate solution.

The carbonate was determined by weighing out 5 grams of coal and treating with acid in the apparatus designed for such work as shown in Fig. 1. This is an improved form of the apparatus described in Bulletin 7 of the Engineering Experiment Station, for the volumetric estimation of carbon dioxide, by absorbing the same in a pipette, as *P* of the figure, and measuring the contraction in the jacketed burette.

From the values thus obtained for these two constituents, it will be seen from the table that the high amounts of both are distributed quite irregularly throughout the State, and very frequently in a sufficiently high amount to make the introduction of their values into any careful analytical work on such coals an essential feature, if trustworthy results are to be forthcoming.

An answer is thus afforded, in such cases at least, to the query of the Committee of the American Chemical Society on Coal Analysis<sup>1</sup>: "Are carbonates likely to be present in the ash in such amount that heating over a blast lamp would lessen the weight appreciably?" An affirmative answer is also indicated in Table 7, where the weight of ash is lessened on blasting by 11.31 per cent of the coal, as in sample 8.

A further suggestion results from these frequent indications of carbon dioxide. The high carbonate content is accompanied by a high lime factor and the question at once occurs as to whether this factor for  $\text{CO}_2$  might not serve as an index of fusibility of the ash quite as accurately as the content of sulphur, since high lime is as promotive of slagging as iron. Numerous tests on the fusibility of ash have confirmed this idea. It is hoped that this matter of the fusibility of coal ash may be taken up for further study in the near future.

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<sup>1</sup>Jour. Am. Chem. Soc. Vol. 20, p. 284, 1898.

TABLE 10

## ANALYSIS OF COAL ASH

(Including Values for CO<sub>2</sub> and Cl)

| Tab.<br>No. | Lab.<br>No. | DESCRIPTION                |             | Ash and Volatile<br>Inorganic Matter<br>Dry Coal<br>Per Cent |                 | MINERAL CONSTITUENTS OF ASH<br>AS OBTAINED BY HIGH FUSION |                  |                                |                                |      |     |
|-------------|-------------|----------------------------|-------------|--------------------------------------------------------------|-----------------|-----------------------------------------------------------|------------------|--------------------------------|--------------------------------|------|-----|
|             |             |                            |             |                                                              |                 | Per Cent                                                  |                  |                                |                                |      |     |
|             |             | LOCATION                   | Seam<br>No. | Ash by<br>Usual<br>Method                                    | CO <sub>2</sub> | Cl                                                        | SiO <sub>2</sub> | Fe <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | CaO  | MgO |
|             |             |                            |             |                                                              |                 |                                                           |                  |                                |                                |      |     |
| 1           | 733         | S. Wilmington, Grundy Co.  | 2           | 8.17                                                         | .15             | None                                                      | 28.8             | 41.1                           | 22.5                           | 7.0  | .6  |
| 2           | 734         | Coal City, Grundy Co.      | 2           | 5.82                                                         | .88             | "                                                         | 22.8             | 32.4                           | 10.2                           | 34.0 | .7  |
| 3           | 1411        | Hollis, Peoria Co.         | 2           | 10.90                                                        | .98             | .27                                                       | 33.3             | 41.8                           | 10.2                           | 16.6 | .7  |
| 4           | 896         | Spillerton, Williamson Co. | 5           | 10.68                                                        | .70             | .31                                                       | 43.2             | 37.9                           | 12.5                           | 3.9  | .5  |
| 5           | 1092        | Equality, Gallatin Co.     | 5           | 10.85                                                        | .72             | None                                                      | 39.5             | 29.6                           | 8.5                            | 23.8 | 1.0 |
| 6           | 1094        | Eldorado, Saline Co.       | 5           | 10.54                                                        | .26             | .15                                                       | 42.8             | 38.3                           | 9.3                            | 8.3  | 1.3 |
| 7           | 1095        | Eldorado, Saline Co.       | 5           | 11.49                                                        | 1.22            | .04                                                       | 32.7             | 33.0                           | 9.0                            | 25.3 | .8  |
| 8           | 1110        | Eldorado, Saline Co.       | 5           | 12.68                                                        | .51             | .14                                                       | 30.6             | 49.7                           | 7.3                            | 13.0 | .8  |
| 9           | 1112        | Harrisburg, Saline Co.     | 5           | 8.99                                                         | .11             | None                                                      | 48.7             | 26.1                           | 22.5                           | 3.2  | 1.2 |
| 10          | 1115        | Ledford, Saline Co.        | 5           | 11.58                                                        | .34             | "                                                         | 40.0             | 26.4                           | 21.8                           | 9.3  | 1.1 |
| 11          | 1116        | Ledford, Saline Co.        | 5           | 9.89                                                         | 1.51            | .05                                                       | 29.4             | 20.0                           | 20.3                           | 26.5 | 2.0 |
| 12          | 540         | Springfield, Sangamon Co.  | 5           | 10.76                                                        | .32             | .08                                                       | 40.5             | 37.0                           | 8.2                            | 11.8 | .5  |
| 13          | 720         | Lincoln, Sangamon Co.      | 5           | 13.81                                                        | .54             | .32                                                       | 35.1             | 22.4                           | 10.2                           | 30.8 | 1.5 |
| 14          | 740         | Springfield, Sangamon Co.  | 5           | 12.75                                                        | .34             | None                                                      | 56.4             | 14.9                           | 18.4                           | 9.1  | 1.2 |
| 15          | 741         | Springfield, Sangamon Co.  | 5           | 12.47                                                        | .85             | .24                                                       | 43.3             | 24.1                           | 9.0                            | 19.9 | 1.2 |
| 16          | 1403        | Bartonville, Peoria Co.    | 5           | 15.46                                                        | 2.48            | None                                                      | 25.7             | 12.9                           | 6.8                            | 54.5 | 1.3 |
| 17          | 1404        | Canton, Fulton Co.         | 5           | 12.52                                                        | 1.30            | .03                                                       | 43.9             | 20.1                           | 12.3                           | 22.4 | 1.3 |
| 18          | 1407        | Edwards Sta., Peoria Co.   | 5           | 16.25                                                        | 2.15            | .03                                                       | 33.1             | 30.6                           | 3.2                            | 31.1 | .8  |
| 19          | 1410        | Maxwell, Peoria Co.        | 5           | 14.78                                                        | 1.57            | None                                                      | 34.3             | 24.8                           | 8.1                            | 31.3 | .7  |
| 20          | 1412        | E. Peoria, Tazewell Co.    | 5           | .....                                                        | .61             | .19                                                       | 45.0             | 26.3                           | 11.6                           | 16.1 | 1.0 |
| 21          | 1413        | Pekin, Tazewell Co.        | 5           | .....                                                        | 1.36            | None                                                      | 43.0             | 17.7                           | 6.6                            | 31.6 | 1.0 |

TABLE 10

## ANALYSIS OF COAL ASH

(Including Values for CO<sub>2</sub> and Cl)—(Continued)

| Tab. No. | Lab. No. | DESCRIPTION                      | Ash and Volatile Inorganic Matter Dry Coal Per Cent |          | MINERAL CONSTITUENTS OF ASH AS OBTAINED BY HIGH FUSION |       |                  |                                |                                |      |     |
|----------|----------|----------------------------------|-----------------------------------------------------|----------|--------------------------------------------------------|-------|------------------|--------------------------------|--------------------------------|------|-----|
|          |          |                                  | LOCATION                                            | Seam No. | Per Cent                                               |       |                  |                                |                                |      |     |
|          |          |                                  |                                                     |          | CO <sub>2</sub>                                        | Cl    | SiO <sub>2</sub> | Fe <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | CaO  | MgO |
|          |          |                                  |                                                     |          | Ash by Usual Method                                    |       |                  |                                |                                |      |     |
| 22       | 557      | Westville, Vermilion Co.         | 6                                                   | 9.15     | 1.08                                                   | .15   | 47.9             | 26.9                           | 18.5                           | 5.6  | 1.1 |
| 23       | 558      | Westville, Vermilion Co.         | 6                                                   | 8.03     | .47                                                    | .15   | 52.9             | 23.8                           | 5.8                            | 17.1 | .3  |
| 24       | 722      | Thayer, Sangamon Co.             | 6                                                   | 11.04    | .19                                                    | .23   | 44.0             | 32.0                           | 13.2                           | 9.8  | 1.0 |
| 25       | 725a     | Collinsville, St. Clair Co.      | 6                                                   | 11.22    | .70                                                    | None  | 50.9             | 17.3                           | 19.5                           | 11.8 | .6  |
| 26       | 725b     | Collinsville, St. Clair Co.      | 6                                                   | .....    | .72                                                    | "     | 48.2             | 18.2                           | 21.3                           | 11.0 | 1.3 |
| 27       | 725c     | Collinsville, St. Clair Co.      | 6                                                   | .....    | .37                                                    | "     | 33.6             | 27.2                           | 11.4                           | 16.8 | 1.2 |
| 28       | 735      | Mt. Olive, Macoupin Co.          | 6                                                   | 10.86    | .36                                                    | .16   | 40.7             | 32.5                           | 17.0                           | 9.8  | .8  |
| 29       | 736      | Mt. Olive, Macoupin Co.          | 6                                                   | 11.40    | .13                                                    | .22   | 49.1             | 32.2                           | 13.5                           | 4.5  | 1.4 |
| 30       | 991      | Belleville, St. Clair Co.        | 6                                                   | 15.80    | .....                                                  | ..... | 44.8             | 20.3                           | 18.6                           | 16.4 | 1.5 |
| 31       | 996      | Germantown, Clinton Co.          | 6                                                   | 10.47    | .44                                                    | .23   | 38.8             | 27.5                           | 19.4                           | 13.2 | 1.1 |
| 32       | 1001     | Lebanon, St. Clair Co.           | 6                                                   | 12.53    | .65                                                    | .12   | 52.9             | 16.7                           | 17.3                           | 11.8 | 1.3 |
| 33       | 1002     | O'Fallon, St. Clair Co.          | 6                                                   | 13.43    | .50                                                    | .16   | 44.3             | 28.4                           | 13.2                           | 11.5 | 1.3 |
| 34       | 1003     | S. W. of O'Fallon, St. Clair Co. | 6                                                   | 12.94    | .76                                                    | None  | 44.4             | 19.3                           | 20.8                           | 16.1 | 1.1 |
| 35       | 1117     | Donkville, Madison Co.           | 6                                                   | 10.59    | .64                                                    | None  | 40.8             | 27.4                           | 13.2                           | 16.9 | 1.6 |
| 36       | 1118     | Troy, Madison Co.                | 6                                                   | 13.65    | .55                                                    | .05   | 44.8             | 19.2                           | 21.2                           | 11.2 | 1.1 |
| 37       | 1119     | Maryville, Madison Co.           | 6                                                   | 11.72    | .71                                                    | .09   | 45.6             | 27.0                           | 5.8                            | 20.8 | .8  |
| 38       | 1176     | Breese, Clinton Co.              | 6                                                   | 13.59    | .40                                                    | .33   | 55.5             | 21.4                           | 5.9                            | 16.4 | .8  |
| 39       | 1178     | Trenton, Clinton Co.             | 6                                                   | 15.56    | 2.48                                                   | .10   | 39.0             | 22.4                           | 6.3                            | 31.7 | .7  |
| 40       | 419      | Zeigler, Franklin Co.            | 6                                                   | 10.11    | .37                                                    | .50   | 59.0             | 3.1                            | 31.0                           | 5.6  | 1.3 |
| 41       | 420      | Zeigler, Franklin Co.            | 7                                                   | 7.53     | .21                                                    | .55   | 54.3             | 9.0                            | 29.1                           | 6.3  | 1.3 |
| 42       | 421      | DuQuoin, Perry Co.               | 7                                                   | 14.71    | .65                                                    | .42   | 55.2             | 8.3                            | 26.6                           | 7.3  | 1.3 |



TABLE 10

## ANALYSIS OF COAL ASH

(Including Values for CO<sub>2</sub> and Cl)—(Concluded)

| DESCRIPTION |             |                              |             | Ash and Volatile<br>Inorganic Matter<br>Dry Coal<br>Per Cent |       |                 |       |                  |                                |                                | MINERAL CONSTITUENTS OF ASH<br>AS OBTAINED BY HIGH FUSION |     |  |  |  |
|-------------|-------------|------------------------------|-------------|--------------------------------------------------------------|-------|-----------------|-------|------------------|--------------------------------|--------------------------------|-----------------------------------------------------------|-----|--|--|--|
| Tab.<br>No. | Lab.<br>No. | LOCATION                     | Seam<br>No. | Ash by<br>Usual<br>Method                                    |       | CO <sub>2</sub> | Cl    | SiO <sub>2</sub> | Fe <sub>2</sub> O <sub>3</sub> | Al <sub>2</sub> O <sub>3</sub> | CaO                                                       | MgO |  |  |  |
|             |             |                              |             |                                                              |       |                 |       |                  |                                |                                |                                                           |     |  |  |  |
| 43          | 422         | DuQuoin, Perry Co.           | 7           | .....                                                        | .28   | 53.9            | .47   | 53.9             | 7.8                            | 28.0                           | 6.7                                                       | 1.0 |  |  |  |
| 44          | 459         | Herrin, Williamson Co.       | 7           | 8.48                                                         | .13   | 50.9            | .13   | 50.9             | 8.1                            | 29.4                           | 1.9                                                       | 1.0 |  |  |  |
| 45          | 460         | Herrin, Williamson Co.       | 7           | 10.13                                                        | .47   | 12              | .12   | 56.1             | 8.1                            | 27.2                           | 5.4                                                       | .9  |  |  |  |
| 46          | 461         | Sesser, Franklin Co.         | 7           | .....                                                        | .28   | 51.4            | .56   | 51.4             | 10.2                           | 31.5                           | 5.7                                                       | 1.1 |  |  |  |
| 47          | 462         | Marion, Williamson Co.       | 7           | 7.66                                                         | None  | 50.1            | None  | 50.1             | 20.0                           | 26.2                           | 2.9                                                       | .8  |  |  |  |
| 48          | 1088        | Herrin, Williamson Co.       | 7           | 10.65                                                        | .35   | 46.2            | ..... | 46.2             | 31.5                           | 9.0                            | 12.8                                                      | .6  |  |  |  |
| 49          | 1120        | Galatia, Saline Co.          | 7           | .....                                                        | 1.20  | 45.4            | .07   | 45.4             | 25.3                           | 16.9                           | 11.6                                                      | .8  |  |  |  |
| 50          | 1121        | Norris City, White Co.       | 7           | 11.50                                                        | .41   | 41.4            | .20   | 41.4             | 34.6                           | 10.6                           | 12.1                                                      | 1.2 |  |  |  |
| 51          | .....       | Taylorville, Sergs. Comp.    | .....       | .....                                                        | ..... | 45.1            | ..... | 45.1             | 21.5                           | 19.8                           | 12.4                                                      | 1.2 |  |  |  |
| 52          | 6121        | Marion, W. Nut.              | 7           | .....                                                        | ..... | 51.7            | ..... | 51.7             | 19.3                           | 24.6                           | 2.4                                                       | 1.0 |  |  |  |
| 53          | 6122        | Lincoln, sergs.              | 5           | .....                                                        | ..... | 49.2            | ..... | 49.2             | 20.7                           | 17.1                           | 11.9                                                      | 1.1 |  |  |  |
| 54          | 6123        | Lincoln, sergs.              | 5           | .....                                                        | ..... | 55.9            | ..... | 55.9             | 13.0                           | 23.6                           | 6.7                                                       | .8  |  |  |  |
| 55          | 6129        | La Salle, W. sergs.          | 5           | .....                                                        | ..... | 40.3            | ..... | 40.3             | 34.0                           | 22.8                           | 2.0                                                       | .9  |  |  |  |
| 56          | 6130        | Pawnee, Lump                 | 6           | .....                                                        | ..... | 33.1            | ..... | 33.1             | 42.5                           | 17.9                           | 5.6                                                       | .9  |  |  |  |
| 57          | 6131        | Pawnee, Lump.                | 6           | .....                                                        | ..... | 54.2            | ..... | 54.2             | 16.4                           | 24.2                           | 4.1                                                       | 1.2 |  |  |  |
| 58          | 6132        | Vigo County, Indiana.        | .....       | .....                                                        | ..... | 32.9            | ..... | 32.9             | 43.8                           | 20.5                           | 2.9                                                       | .9  |  |  |  |
| 59          | 6133        | Vigo County, Indiana.        | .....       | .....                                                        | ..... | 35.1            | ..... | 35.1             | 35.6                           | 25.3                           | 2.3                                                       | .8  |  |  |  |
| 60          | 6134        | Sullivan Co., Indiana.       | .....       | .....                                                        | ..... | 45.8            | ..... | 45.8             | 20.2                           | 28.3                           | 5.4                                                       | .0  |  |  |  |
| 61          | 6135        | Sullivan Co., Indiana.       | .....       | .....                                                        | ..... | 27.1            | ..... | 27.1             | 52.3                           | 14.1                           | 4.4                                                       | 1.2 |  |  |  |
| 62          | 6290        | Marion, Williamson Co., Ill. | 7           | .....                                                        | ..... | 54.1            | ..... | 54.1             | 12.1                           | 23.8                           | 6.7                                                       | 1.2 |  |  |  |

## V. SUMMARY

The principles developed by the foregoing discussion may be stated as follows:

1. Ordinarily the total inorganic or non-coal constituent is expressed by the formula

$$\text{Total Inorganic Matter} = M + 1.08 A + 22/40 S$$

in which M = moisture, A = ash, and S = sulphur. The formula for calculating the heat value for unit coal, therefore, basing the calculation upon wet coal values, would be

$$\text{B. t. u. of Unit Coal} = \frac{\text{Indicated (wet) B. t. u.} - 5000 S}{1.00 - (M + 1.08 A + 22/40 S)}$$

and for dry coal:

$$\text{B. t. u. of Unit Coal} = \frac{\text{Indicated (dry) B. t. u.} - 5000 S}{1.00 - (1.08 A + 22/40 S)}$$

2. A coal of unknown character as to its carbonate content should be subjected to a carbonate determination readily effected by liberating the  $\text{CO}_2$  with acid and measuring the same by weight or volume. Where carbonates are found to exist in any considerable quantity, say over 0.3 per cent  $\text{CO}_2$ , the ash determination should be made by blasting in a platinum crucible to constant weight, and the ash as thus determined corrected by adding the weight found for  $\text{CO}_2$ . Further, since this method of driving the weight of ash will drive off the chlorine present, this constituent should also be determined and the amount as Cl added to the weight of ash.

It has been possible to apply the foregoing principles to a large number of analyses which have been made in this laboratory. Some from the same mine extending over a considerable period of time afford a good opportunity of verifying the constancy of the unit coal values from the same mine. Others from the same geological seam, extending over a considerable area, as well as those from neighboring mines, serve to demonstrate a positive relationship and, so far as they are available, establish the unit values for their respective regions. An extension of these data has been prepared and arranged in tables following

this discussion. In addition to the results obtained in our own laboratory, the various coal values as published by the Ohio State Survey<sup>1</sup> (Appendix A) and the United States Geological Survey<sup>2</sup> (Appendix B) have been calculated to unit values by the formula already developed and indicated at the head of the column for "Unit Coal." A most interesting study is there made possible of the constancy of values for a given type of coal or for a given region.

The application which the facts of the tables may be made to serve are many and of far-reaching importance. The real value and the extent of this service hinge upon the accuracy with which we may differentiate between the actual or unit coal and the true ash content. It is believed that the methods and formulas herein proposed are accurate within the limits of variation, inherent in the composition of the unit substance itself, and in the manipulation and methods of analysis employed. Concerning this latter point, it is obviously impossible in applying the calculations to analytical values already published, to take account of errors in ash determination, due for example to the presence of carbonate of lime. Some of the discrepancies in unit values, therefore, may be due to this fact. Moreover, some of the samples grouped by counties may be from different seams and hence show a difference in their unit values. It has not been practicable to give more detail of location or deposit than is contained in the tables, but the facts thus presented seem to have sufficient value to warrant their publication in this form.

An inspection of Table 10, (p. 31), shows a number of coals with over 2 per cent of  $\text{CO}_2$  present. This represents approximately 5 per cent of calcium carbonate. In the Mahler type of calorimeter, this material is decomposed, representing a loss of heat amounting to about 40 B. t. u. for each 5 per cent of calcium carbonate present. A question is therefore raised as to the desirability of correcting heat values obtained by that instrument, to take account of this reaction in the calorimeter.

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<sup>1</sup>Geological Survey of Ohio, Fourth Series, Bul. No. 9, 1908.

<sup>2</sup>United States Geological Survey, Bulletins No. 261, No. 290, and No. 332.



## VI. CONCLUSIONS

1. The actual or unit coal of a given deposit or region is remarkably uniform in composition, as shown by the constancy of heat values, when calculated to such unit substance.

2. The true percentage content of the actual or unit coal hinges upon the correct determination of the inorganic constituents of the coal. The present methods of analysis fail to take account of such constituents as the hydration of the shaley or clayey portions of the ash or the carbon dioxide content of earthy carbonates. The presence of chlorine compounds may sometimes be sufficient in amount to require consideration and estimation.

3. Coal with an ash of unknown composition should be examined for carbonates and chlorides. If the combined amount of these constituents approximates 0.5 per cent, the ash determination should be made at a temperature sufficiently high for their complete elimination, and a correction made for the ash value thus obtained by adding the amount of  $\text{CO}_2$  and Cl found.

4. Apart from the corrections which may be called for on account of the presence of  $\text{CO}_2$  or Cl, a factor for hydration is necessary, amounting to 8 per cent of the ash as determined, minus the ferric oxide resulting from the decomposition of the iron pyrites.

5. The assembling of the corrections indicated may be embodied in a simple formula, easy of application, and under two headings as follows:

*For coals free from carbonates and chlorides*

$$\text{Unit B. t. u.} = \frac{\text{Indicated Dry B. t. u.} - 5000 \text{ S}}{1.00 - (1.08 \text{ Ash} + 22/40 \text{ S})}$$

*For coals with carbonates and chlorides*

$$\text{Unit B. t. u.} = \frac{\text{Indicated Dry B. t. u.} - 5000 \text{ S}}{1.00 - [(\text{Ash at high temp.} + \text{CO}_2 + \text{Cl}) 1.08 + 22/40 \text{ S.}]}$$

## VII. TABULATION OF CALCULATED VALUES FOR UNIT COAL

From the tables following, (Tables 11 to 19 inclusive), not only is there evidence of a constancy of values for a given area, but, conversely, a given type of fuel over widely separated areas has a value which varies between relatively narrow limits and may be made to serve as an index of the kind or type and probably the region from which the material comes. From an inspection of these and other data a tentative series of values defining the suggested limits for the generally recognized fuel types is given in Table 11.

TABLE 11

## CLASSIFICATION OF FUEL TYPES BY HEAT VALUES FOR UNIT OR ACTUAL ORGANIC SUBSTANCE

|                                              |                |
|----------------------------------------------|----------------|
| Cellulose and wood.....                      | 6500 to 7800   |
| Peat.....                                    | 7800 to 11500  |
| Lignite-brown.....                           | 11500 to 12500 |
| Lignite-black.....                           | 12500 to 13500 |
| Sub-bituminous Coal.....                     | 13500 to 14200 |
| Bituminous Coal (mid continental field)..... | 14200 to 15000 |
| Bituminous Coal (eastern field).....         | 15000 to 16000 |
| Semi-anthracite and Semi-bituminous.....     | 15500 to 16000 |
| Anthracite.....                              | 15000 to 15500 |

TABLE 12

## COAL RESULTS

From Continuous Deliveries, September 1, 1907 to September 1, 1908.

Each Sample Represents 5 Cars or 250 Tons, and is a Composite of 5 Separate Samples.

Shipments all from the Same Mine, Christian Co., Ill.

| Lab.<br>No. | ANALYSES OF SAMPLES AS RECEIVED |       |         |          | "Unit Coal"<br>Basis                                                         | Variation<br>from Av-<br>erage<br>B. t. u. |
|-------------|---------------------------------|-------|---------|----------|------------------------------------------------------------------------------|--------------------------------------------|
|             | Moisture                        | Ash   | Sulphur | B. t. u. | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |                                            |
| 933         | 13.16                           | 17.07 | 4.39    | 9665     | 14313                                                                        | —160                                       |
| 934         | 10.89                           | 17.34 | 4.87    | 10104    | 14564                                                                        | + 91                                       |
| 935         | 13.49                           | 15.14 | 3.99    | 10082    | 14539                                                                        | + 66                                       |
| 936         | 13.76                           | 16.26 | 4.01    | 9845     | 14507                                                                        | + 34                                       |
| 937         | 14.00                           | 16.97 | 4.41    | 9680     | 14499                                                                        | + 26                                       |
| 938         | 12.55                           | 17.40 | 4.19    | 9883     | 14576                                                                        | +103                                       |
| 939         | 12.57                           | 18.70 | 4.43    | 9709     | 14643                                                                        | +170                                       |
| 940         | 12.99                           | 16.25 | 4.10    | 9971     | 14533                                                                        | + 60                                       |
| 941         | 12.71                           | 17.27 | 4.55    | 9871     | 14580                                                                        | +107                                       |
| 942         | 12.18                           | 18.53 | 5.35    | 9724     | 14577                                                                        | +104                                       |
| 943         | 11.52                           | 16.13 | 4.36    | 10211    | 14554                                                                        | + 81                                       |
| 944         | 12.21                           | 15.31 | 4.32    | 10278    | 14608                                                                        | +135                                       |
| 945         | 13.53                           | 16.14 | 4.38    | 9824     | 14420                                                                        | — 53                                       |
| 946         | 14.99                           | 14.96 | 4.15    | 9885     | 14537                                                                        | + 64                                       |
| 947         | 15.07                           | 15.09 | 4.27    | 9825     | 14501                                                                        | + 28                                       |
| 948         | 14.25                           | 15.51 | 3.91    | 9896     | 14510                                                                        | + 37                                       |
| 949         | 12.98                           | 15.25 | 3.70    | 10076    | 14437                                                                        | — 36                                       |
| 957         | 13.17                           | 16.40 | 4.16    | 9880     | 14472                                                                        | — 1                                        |
| 990         | 13.03                           | 18.05 | 4.39    | 9773     | 14683                                                                        | +210                                       |
| 1024        | 14.59                           | 16.20 | 4.18    | 9830     | 14664                                                                        | +191                                       |
| 1025        | 13.38                           | 17.51 | 4.19    | 9747     | 14580                                                                        | +107                                       |
| 1026        | 14.28                           | 16.31 | 4.71    | 9840     | 14558                                                                        | +185                                       |
| 1027        | 13.84                           | 16.56 | 4.23    | 9842     | 14602                                                                        | +129                                       |
| 1071        | 13.88                           | 16.06 | 4.51    | 9868     | 14543                                                                        | + 70                                       |
| 1072        | 13.66                           | 16.31 | 4.46    | 9837     | 14505                                                                        | + 32                                       |
| 1073        | 12.99                           | 15.71 | 4.15    | 10076    | 14563                                                                        | + 90                                       |
| 1074        | 12.43                           | 17.95 | 4.66    | 9834     | 14631                                                                        | +158                                       |
| 1075        | 12.70                           | 17.01 | 4.12    | 9857     | 14478                                                                        | — 5                                        |
| 1076        | 13.79                           | 18.63 | 4.95    | 9497     | 14595                                                                        | +122                                       |
| 1077        | 13.62                           | 15.90 | 4.36    | 9935     | 14544                                                                        | + 71                                       |
| 1180        | 13.45                           | 16.68 | 4.00    | 9801     | 14472                                                                        | — 1                                        |
| 1181        | 13.17                           | 17.95 | 4.85    | 9607     | 14457                                                                        | — 16                                       |
| 1182        | 13.49                           | 13.36 | 3.97    | 9964     | 14415                                                                        | — 58                                       |
| 1183        | 12.16                           | 19.20 | 5.01    | 9556     | 14462                                                                        | — 11                                       |
| 1184        | 11.90                           | 17.16 | 4.55    | 9925     | 14458                                                                        | — 15                                       |
| 1185        | 12.97                           | 16.63 | 4.60    | 9893     | 14522                                                                        | + 49                                       |
| 1186        | 13.73                           | 16.66 | 4.34    | 9795     | 14536                                                                        | + 63                                       |
| 1187        | 13.80                           | 16.10 | 4.27    | 9884     | 14550                                                                        | + 77                                       |
| 1188        | 14.28                           | 15.84 | 4.54    | 9763     | 14424                                                                        | — 49                                       |
| 1204        | 14.51                           | 18.04 | 4.35    | 9464     | 14533                                                                        | + 60                                       |



TABLE 12  
COAL RESULTS—(Concluded)

| Lab.<br>No. | ANALYSES OF SAMPLES AS RECEIVED |       |         |          | "Unit Coal"<br>Basis                      | Variation<br>from Av-<br>erage<br>B. t. u. |
|-------------|---------------------------------|-------|---------|----------|-------------------------------------------|--------------------------------------------|
|             | Moisture                        | Ash   | Sulphur | B. t. u. | B. t. u. — 5000 S                         |                                            |
|             |                                 |       |         |          | 1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |                                            |
| 1205        | 14.13                           | 16.31 | 4.85    | 9746     | 14488                                     | + 15                                       |
| 1272        | 15.81                           | 15.18 | 3.86    | 9650     | 14399                                     | — 74                                       |
| 1273        | 15.21                           | 14.45 | 4.04    | 9910     | 14498                                     | + 25                                       |
| 1274        | 15.40                           | 16.08 | 5.03    | 9560     | 14440                                     | — 33                                       |
| 1275        | 14.04                           | 16.44 | 4.52    | 9694     | 14409                                     | — 64                                       |
| 1276        | 14.35                           | 18.13 | 4.62    | 9315     | 14299                                     | — 174                                      |
| 1326        | 14.81                           | 16.56 | 4.22    | 9540     | 14354                                     | — 119                                      |
| 1327        | 13.46                           | 17.87 | 4.65    | 9505     | 14335                                     | — 138                                      |
| 1328        | 13.56                           | 17.53 | 4.67    | 9568     | 14373                                     | — 100                                      |
| 1329        | 14.98                           | 14.37 | 3.90    | 9928     | 14451                                     | — 22                                       |
| 1330        | 14.59                           | 16.63 | 4.34    | 9614     | 14444                                     | — 29                                       |
| 1331        | 14.10                           | 17.42 | 4.82    | 9592     | 14511                                     | + 38                                       |
| 1332        | 13.13                           | 16.12 | 4.58    | 9783     | 14272                                     | — 201                                      |
| 1447        | 13.28                           | 17.10 | 4.19    | 9670     | 14346                                     | — 127                                      |
| 1448        | 12.62                           | 18.18 | 4.46    | 9590     | 14344                                     | — 129                                      |
| 1449        | 13.31                           | 18.15 | 4.50    | 9584     | 14485                                     | + 12                                       |
| 1450        | 13.21                           | 16.16 | 4.21    | 9852     | 14385                                     | — 88                                       |
| 1451        | 13.32                           | 17.01 | 4.28    | 9656     | 14313                                     | — 160                                      |
| 1695        | 15.31                           | 13.19 | 3.61    | 9999     | 14341                                     | — 132                                      |
| 1696        | 16.12                           | 13.10 | 3.76    | 9890     | 14339                                     | — 134                                      |
| 1697        | 15.62                           | 14.29 | 3.61    | 9782     | 14338                                     | — 135                                      |
| 1759        | 14.02                           | 15.62 | 4.43    | 9817     | 14392                                     | — 81                                       |
| 1760        | 13.83                           | 16.54 | 4.49    | 9676     | 14354                                     | — 119                                      |
| 1789        | 13.49                           | 19.41 | 4.07    | 9331     | 14416                                     | — 57                                       |
| 1832        | 14.09                           | 17.22 | 4.17    | 9605     | 14451                                     | — 22                                       |
| 1833        | 13.56                           | 17.07 | 3.93    | 9704     | 14439                                     | — 34                                       |
| 1834        | 13.56                           | 17.50 | 4.24    | 9590     | 14381                                     | — 92                                       |
| Av....      | 13.65                           | 16.58 | 4.35    | 9779     | 14475                                     | ± 82                                       |

TABLE 13  
COAL RESULTS

From Continuous Deliveries September 1, 1908, to May 1, 1909

Each Sample represents 300 Tons

Shipments all from the Same Mine, Vermilion Co., Ill.

| Lab.<br>No. | ANALYSES OF SAMPLES AS RECEIVED |       |         |          | "Unit Coal"<br>Basis                                           | Variation<br>from Av-<br>erage<br>B. t. u. |
|-------------|---------------------------------|-------|---------|----------|----------------------------------------------------------------|--------------------------------------------|
|             | Moisture                        | Ash   | Sulphur | B. t. u. | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |                                            |
| 1879        | 12.92                           | 16.58 | 3.82    | 9992     | 14613                                                          | — 143                                      |
| 1880        | 14.22                           | 18.16 | 4.51    | 9540     | 14624                                                          | — 132                                      |
| 1881        | 12.45                           | 17.22 | 4.14    | 9950     | 14608                                                          | — 148                                      |
| 1883        | 13.00                           | 19.48 | 4.31    | 9501     | 14601                                                          | — 155                                      |
| 1896        | 12.08                           | 17.13 | 3.67    | 10160    | 14801                                                          | + 45                                       |
| 1897        | 12.67                           | 16.90 | 4.26    | 10062    | 14757                                                          | + 1                                        |
| 1898        | 12.71                           | 16.79 | 4.22    | 10071    | 14752                                                          | — 4                                        |
| 1899        | 12.36                           | 18.80 | 5.17    | 9801     | 14794                                                          | + 38                                       |
| 1900        | 12.36                           | 16.53 | 5.07    | 10170    | 14800                                                          | + 44                                       |
| 1902        | 12.70                           | 15.20 | 3.89    | 10269    | 14655                                                          | — 101                                      |
| 1903        | 12.65                           | 15.27 | 3.78    | 10208    | 14567                                                          | — 189                                      |
| 1905        | 12.38                           | 18.00 | 4.59    | 9913     | 14747                                                          | — 9                                        |
| 1906        | 12.46                           | 18.30 | 4.21    | 9787     | 14629                                                          | — 127                                      |
| 1908        | 11.76                           | 16.12 | 3.48    | 10402    | 14840                                                          | + 84                                       |
| 1909        | 11.74                           | 15.10 | 3.93    | 10440    | 14677                                                          | — 79                                       |
| 1911        | 12.34                           | 16.19 | 4.23    | 10324    | 14903                                                          | + 147                                      |
| 1912        | 12.59                           | 18.25 | 4.10    | 9772     | 14620                                                          | — 136                                      |
| 1919        | 16.76                           | 16.68 | 3.70    | 9512     | 14760                                                          | + 4                                        |
| 1920        | 16.92                           | 18.20 | 3.83    | 9232     | 14745                                                          | — 11                                       |
| 1934        | 12.93                           | 16.44 | 3.54    | 10200    | 14878                                                          | + 122                                      |
| 1942        | 12.72                           | 17.62 | 4.07    | 9949     | 14763                                                          | + 7                                        |
| 1943        | 15.03                           | 16.45 | 4.09    | 9846     | 14844                                                          | + 88                                       |
| 1947        | 13.90                           | 18.31 | 4.08    | 9689     | 14800                                                          | + 44                                       |
| 1990        | 14.47                           | 15.57 | 3.85    | 10021    | 14759                                                          | + 3                                        |
| 1991        | 13.31                           | 18.08 | 4.35    | 10020    | 15134                                                          | + 378*                                     |
| 1987        | 12.80                           | 14.51 | 3.64    | 10476    | 14805                                                          | + 49                                       |
| 1988        | 12.68                           | 14.54 | 3.80    | 10508    | 14840                                                          | + 84                                       |
| 1993        | 13.19                           | 17.33 | 4.16    | 9931     | 14777                                                          | + 21                                       |
| 1994        | 13.31                           | 18.44 | 4.15    | 9849     | 14947                                                          | + 191                                      |
| 1996        | 11.85                           | 20.36 | 5.47    | 9720     | 14958                                                          | + 202                                      |
| 1997        | 12.05                           | 20.83 | 4.13    | 9512     | 14728                                                          | — 28                                       |
| 2007        | 13.73                           | 19.23 | 3.91    | 9527     | 14729                                                          | — 27                                       |
| 2008        | 13.53                           | 18.60 | 4.33    | 9638     | 14720                                                          | — 36                                       |
| 2016        | 13.38                           | 19.72 | 4.42    | 9583     | 14886                                                          | + 130                                      |
| 2017        | 13.28                           | 18.24 | 4.56    | 9797     | 14833                                                          | + 77                                       |
| 2013        | 12.48                           | 21.14 | 5.11    | 9348     | 14693                                                          | — 63                                       |
| 2014        | 12.89                           | 18.78 | 3.78    | 9742     | 14880                                                          | + 124                                      |
| 2029        | 14.24                           | 19.64 | 4.47    | 9431     | 14829                                                          | + 73                                       |
| 2030        | 15.90                           | 16.35 | 3.75    | 9667     | 14724                                                          | — 32                                       |
| 2031        | 14.11                           | 17.36 | 3.97    | 9677     | 14591                                                          | — 165                                      |
| 2032        | 13.66                           | 15.43 | 3.77    | 10173    | 14767                                                          | + 11                                       |

\* Probably due to error in ash determination.

TABLE 13  
COAL RESULTS—(Concluded)

| Lab.<br>No. | ANALYSES OF SAMPLES AS RECEIVED |       |         |          | "Unit Coal"<br>Basis                                                         | Variation<br>from Av-<br>erage<br>B. t. u. |
|-------------|---------------------------------|-------|---------|----------|------------------------------------------------------------------------------|--------------------------------------------|
|             | Moisture                        | Ash   | Sulphur | B. t. u. | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |                                            |
| 2057        | 13.61                           | 15.71 | 4.13    | 10128    | 14775                                                                        | + 19                                       |
| 2071        | 12.16                           | 18.31 | 3.98    | 9986     | 14856                                                                        | +100                                       |
| 2072        | 12.22                           | 18.93 | 3.93    | 9857     | 14821                                                                        | + 65                                       |
| 2073        | 13.10                           | 20.38 | 3.99    | 9520     | 14864                                                                        | +108                                       |
| 2074        | 12.47                           | 19.37 | 4.04    | 9791     | 14892                                                                        | +136                                       |
| 2106        | 13.31                           | 17.49 | 4.03    | 9816     | 14660                                                                        | — 96                                       |
| 2107        | 14.07                           | 17.50 | 4.43    | 9742     | 14739                                                                        | — 17                                       |
| 2108        | 13.12                           | 17.25 | 4.41    | 9987     | 14837                                                                        | + 81                                       |
| 2145        | 12.81                           | 16.82 | 3.98    | 10066    | 14764                                                                        | + 8                                        |
| 2146        | 13.97                           | 15.64 | 4.76    | 9813     | 14632                                                                        | —124                                       |
| 2147        | 13.19                           | 17.68 | 4.21    | 9805     | 14668                                                                        | — 68                                       |
| 2159        | 13.30                           | 17.98 | 4.17    | 9831     | 14805                                                                        | + 49                                       |
| 2160        | 12.20                           | 20.14 | 4.78    | 9628     | 14805                                                                        | + 49                                       |
| 2161        | 13.12                           | 17.61 | 4.34    | 9900     | 14790                                                                        | + 34                                       |
| 2178        | 14.83                           | 19.77 | 3.90    | 9319     | 14793                                                                        | + 37                                       |
| 2179        | 14.01                           | 17.92 | 4.13    | 9858     | 14993                                                                        | +237*                                      |
| 2180        | 13.03                           | 19.92 | 4.11    | 9503     | 14710                                                                        | — 46                                       |
| 2232        | 14.07                           | 17.40 | 4.12    | 9815     | 14813                                                                        | + 57                                       |
| 2233        | 13.26                           | 19.54 | 4.25    | 9381     | 14483                                                                        | —273*                                      |
| 2234        | 12.26                           | 18.90 | 3.95    | 9611     | 14446                                                                        | —310*                                      |
| 2235        | 13.02                           | 17.94 | 4.46    | 9706     | 14547                                                                        | —209                                       |
| 2304        | 15.07                           | 19.03 | 4.42    | 9346     | 14730                                                                        | — 26                                       |
| 2305        | 14.22                           | 16.93 | 4.81    | 9718     | 14614                                                                        | —142                                       |
| 2324        | 15.16                           | 16.98 | 3.72    | 9706     | 14771                                                                        | + 15                                       |
| 2325        | 15.33                           | 16.60 | 3.77    | 9792     | 14849                                                                        | + 93                                       |
| 2326        | 11.99                           | 19.10 | 4.13    | 9801     | 14735                                                                        | — 21                                       |
| 2369        | 12.00                           | 18.42 | 3.92    | 9900     | 14712                                                                        | — 44                                       |
| 2370        | 14.29                           | 18.74 | 4.63    | 9498     | 14727                                                                        | — 29                                       |
| 2371        | 13.28                           | 17.33 | 4.17    | 9897     | 14744                                                                        | — 12                                       |
| 2416        | 13.55                           | 18.55 | 4.48    | 9630     | 14706                                                                        | — 50                                       |
| Av. . . .   | 13.30                           | 17.79 | 4.18    | 9828     | 14756                                                                        | ± 86                                       |

\* Probably due to error in ash determination.



TABLE 14  
COAL RESULTS

Run-of-Mine Coal from Two Mines, Boulder Co., Colo.

| No.     | ANALYSES OF SAMPLES AS RECEIVED |      |      |          | "Unit Coal"<br>Basis                                         | Variation<br>from Av-<br>erage<br>B. t. u. |
|---------|---------------------------------|------|------|----------|--------------------------------------------------------------|--------------------------------------------|
|         | Moisture                        | Ash  | Sul. | B. t. u. | B. t. u. — 5000S<br>1.00—<br>(1.08 Ash + $\frac{22}{40}$ S.) |                                            |
| 13      | 19.59                           | 8.38 | .52  | 9349     | 13118                                                        | +120                                       |
| 15      | 20.18                           | 8.15 | .39  | 9362     | 13193                                                        | +195                                       |
| 19      | 20.26                           | 6.85 | .38  | 9434     | 13053                                                        | + 55                                       |
| 20      | 19.64                           | 6.83 | .36  | 9519     | 13054                                                        | + 56                                       |
| 22      | 19.49                           | 7.23 | .48  | 9580     | 13192                                                        | +194                                       |
| 24      | 19.43                           | 5.77 | .38  | 9625     | 12958                                                        | - 40                                       |
| 25      | 19.12                           | 7.16 | .42  | 9620     | 13164                                                        | +166                                       |
| 27      | 20.43                           | 6.40 | .36  | 9512     | 13102                                                        | +104                                       |
| 30      | 19.65                           | 8.55 | .41  | 9271     | 13048                                                        | + 50                                       |
| 31      | 19.91                           | 6.75 | .38  | 9425     | 12958                                                        | - 40                                       |
| 35      | 20.32                           | 7.85 | .44  | 9431     | 13260                                                        | +262                                       |
| 37      | 19.71                           | 4.88 | .38  | 9779     | 13046                                                        | + 48                                       |
| 5       | 20.23                           | 5.81 | .35  | 9373     | 12761                                                        | -237                                       |
| 7       | 19.73                           | 5.08 | .29  | 9598     | 12842                                                        | -156                                       |
| 8       | 19.64                           | 5.97 | .30  | 9497     | 12859                                                        | -139                                       |
| 9       | 19.83                           | 5.54 | .29  | 9573     | 12911                                                        | - 87                                       |
| 13      | 20.06                           | 5.51 | .33  | 9551     | 12917                                                        | - 81                                       |
| 18      | 20.08                           | 4.82 | .38  | 9632     | 12902                                                        | - 96                                       |
| 19      | 19.96                           | 5.63 | .30  | 9588     | 12972                                                        | - 26                                       |
| 34      | 19.99                           | 6.55 | .40  | 9441     | 12955                                                        | - 43                                       |
| 38      | 19.38                           | 5.11 | .27  | 9712     | 12939                                                        | - 59                                       |
| 42      | 19.96                           | 6.95 | .25  | 9422     | 12998                                                        | 00                                         |
| 45      | 20.56                           | 5.60 | .26  | 9428     | 12853                                                        | -145                                       |
| 76      | 18.09                           | 5.56 | .41  | 9835     | 12907                                                        | - 91                                       |
| Av..... | 19.80                           | 6.37 | .36  | 9523     | 12998                                                        | ±104                                       |

TABLE 15

## COAL RESULTS

Run-of-Mine Coal from One Mine, Las Animas Co., Colo.

| No.         | ANALYSES OF SAMPLES AS RECEIVED |       |      |          | "Unit Coal"<br>Basis                                          | Variation<br>from Av-<br>erage<br>B. t. u. |
|-------------|---------------------------------|-------|------|----------|---------------------------------------------------------------|--------------------------------------------|
|             | Moisture                        | Ash   | Sul. | B. t. u. | B. t. u. — 5000S<br>1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |                                            |
| 2           | 2.25                            | 9.72  | .89  | 13309    | 15288                                                         | — 4                                        |
| 10          | 2.40                            | 11.33 | .68  | 13066    | 15334                                                         | + 42                                       |
| 12          | 2.51                            | 14.49 | .68  | 12547    | 15359                                                         | + 67                                       |
| 14          | 2.63                            | 11.32 | .61  | 13033    | 15332                                                         | + 40                                       |
| 15          | 2.93                            | 11.53 | .61  | 13065    | 15465                                                         | + 173                                      |
| 16          | 2.57                            | 12.81 | .60  | 12842    | 15386                                                         | + 92                                       |
| 21          | 2.80                            | 20.17 | .65  | 11643    | 15468                                                         | + 176                                      |
| 23          | 2.26                            | 9.45  | .60  | 13297    | 15214                                                         | — 78                                       |
| 25          | 2.43                            | 14.86 | .60  | 12572    | 15448                                                         | + 156                                      |
| 33          | 2.02                            | 11.14 | .63  | 13025    | 15144                                                         | — 148                                      |
| 37          | 2.95                            | 13.01 | .59  | 12532    | 15121                                                         | — 171                                      |
| 41          | 3.65                            | 12.22 | .63  | 12584    | 15159                                                         | — 133                                      |
| 44          | 2.48                            | 12.77 | .58  | 12722    | 15218                                                         | — 74                                       |
| 46          | 2.19                            | 11.57 | .61  | 12904    | 15150                                                         | — 142                                      |
| Av. . . . . | 2.58                            | 12.59 | .64  | 12796    | 15292                                                         | ± 107                                      |

TABLE 16  
ILLINOIS "No. 2" COAL

| Lab.<br>No. | LOCALITY          | Total<br>Mois-<br>ture | REFERRED TO<br>DRY COAL |      |          | "Unit Coal"<br>Basis<br><br>B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |
|-------------|-------------------|------------------------|-------------------------|------|----------|--------------------------------------------------------------------------------------------|
|             |                   |                        | Ash                     | Sul. | B. t. u. |                                                                                            |
| 1764        | Bureau Co.....    | 15.61                  | 9.59                    | 4.29 | 13008    | 14657                                                                                      |
| 1769        | Bureau Co.....    | 15.99                  | 8.96                    | 4.04 | 13191    | 14743                                                                                      |
| 1860        | Brown Co.....     | 15.60                  | 10.02                   | 6.01 | 13099    | 14904                                                                                      |
| 1869        | Christian Co..... | 11.54                  | 10.08                   | 4.38 | 13148    | 14912                                                                                      |
| 1811        | Fulton Co.....    | 15.37                  | 7.55                    | 3.67 | 13558    | 14888                                                                                      |
| 1839        | Green Co.....     | 14.93                  | 12.43                   | 5.79 | 12581    | 14739                                                                                      |
| 1840        | Green Co.....     | 15.04                  | 12.38                   | 6.03 | 12538    | 14687                                                                                      |
| 733         | Grundy Co.....    | 14.69                  | 8.17                    | 3.62 | 13217    | 14616                                                                                      |
| 1787        | Grundy Co.....    | 17.18                  | 6.82                    | 3.11 | 13450    | 14622                                                                                      |
| 734         | Grundy Co.....    | 14.16                  | 5.82                    | 1.83 | 13436    | 14395                                                                                      |
| 1861        | Hancock Co.....   | 13.48                  | 6.88                    | 4.29 | 13516    | 14744                                                                                      |
| 1875        | Jackson Co.....   | 14.25                  | 4.99                    | .79  | 14113    | 14943                                                                                      |
| 1878        | Jackson Co.....   | 12.73                  | 4.75                    | .71  | 14115    | 14902                                                                                      |
| 1876        | Jackson Co.....   | 9.00                   | 6.87                    | 2.02 | 13799    | 14975                                                                                      |
| 1765        | La Salle Co.....  | 14.03                  | 9.77                    | 3.36 | 13033    | 14686                                                                                      |
| 1785        | La Salle Co.....  | 12.41                  | 8.89                    | 3.23 | 13329    | 14858                                                                                      |
| 1768        | LaSalle Co.....   | 15.36                  | 14.03                   | 5.34 | 12241    | 14618                                                                                      |
| 1775        | Marshall Co.....  | 14.60                  | 7.29                    | 1.90 | 13539    | 14761                                                                                      |
| 1795        | Marshall Co.....  | 13.54                  | 6.66                    | 2.90 | 13743    | 14908                                                                                      |
| 1831        | McDonough Co..... | 16.42                  | 8.18                    | 3.23 | 13418    | 14829                                                                                      |
| 1748        | Mc Lean Co.....   | 12.02                  | 10.13                   | 3.36 | 12980    | 14704                                                                                      |
| 1857        | Mercer Co.....    | 17.56                  | 11.58                   | 5.47 | 12666    | 14669                                                                                      |
| 1411        | Peoria Co.....    | 12.05                  | 10.90                   | 4.48 | 12866    | 14739                                                                                      |
| 1802        | Warren Co.....    | 18.52                  | 5.45                    | 3.20 | 13650    | 14606                                                                                      |
| 1793        | Woodford Co.....  | 16.18                  | 8.33                    | 3.55 | 13361    | 14802                                                                                      |

TABLE 17  
ILLINOIS "No. 5" COAL FROM SOUTHERN PART OF STATE

| Lab.<br>No. | LOCALITY           | Total<br>Mois-<br>ture | REFERRED TO<br>DRY COAL |      |          | "Unit Coal"<br>Basis                                                         |
|-------------|--------------------|------------------------|-------------------------|------|----------|------------------------------------------------------------------------------|
|             |                    |                        | Ash                     | Sul. | B. t. u. | B. t. u. - 5000 S<br>1.00 -<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| 1092        | Gallatin Co.....   | 4.47                   | 10.85                   | 3.72 | 13235    | 15133                                                                        |
| 1094        | Saline Co.....     | 6.03                   | 10.54                   | 3.12 | 13212    | 15024                                                                        |
| 1095        | Saline Co.....     | 4.89                   | 11.49                   | 4.16 | 12931    | 14916                                                                        |
| 1110        | Saline Co.....     | 4.34                   | 12.68                   | 6.12 | 12879    | 15157                                                                        |
| 1111        | Saline Co.....     | 6.64                   | 9.21                    | 2.35 | 13367    | 14927                                                                        |
| 1112        | Saline Co.....     | 6.10                   | 8.99                    | 3.52 | 13415    | 15019                                                                        |
| 1113        | Saline Co.....     | 5.97                   | 7.62                    | 2.30 | 13700    | 15011                                                                        |
| 1114        | Saline Co.....     | 4.43                   | 9.04                    | 2.47 | 13450    | 14993                                                                        |
| 1115        | Saline Co.....     | 6.04                   | 11.58                   | 3.26 | 12942    | 14911                                                                        |
| 1116        | Saline Co.....     | 6.13                   | 9.89                    | 2.37 | 13298    | 14973                                                                        |
| 896         | Williamson Co..... | 6.29                   | 10.68                   | 3.86 | 13073    | 14930                                                                        |
| 1809        | Williamson Co..... | 6.47                   | 12.53                   | 3.62 | 12853    | 15000                                                                        |



TABLE 18

ILLINOIS "No. 5" COAL FROM CENTRAL PART OF STATE

| Lab.<br>No. | LOCALITY           | Total<br>Mois-<br>ture | REFERRED TO<br>DRY COAL |      |          | "Unit Coal"<br>Basis                      |
|-------------|--------------------|------------------------|-------------------------|------|----------|-------------------------------------------|
|             |                    |                        | Ash                     | Sul. | B. t. u. | B. t. u. — 5000 S                         |
|             |                    |                        |                         |      |          | 1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |
| 1404        | Fulton Co.....     | 15.09                  | 12.52                   | 3.79 | 12450    | 14527                                     |
| 1807        | Fulton Co.....     | 15.03                  | 12.98                   | 2.95 | 12389    | 14510                                     |
| 1808        | Fulton Co.....     | 15.49                  | 13.43                   | 3.81 | 12364    | 14594                                     |
| 1856        | Fulton Co.....     | 15.44                  | 12.22                   | 4.17 | 12666    | 14740                                     |
| 1771        | La Salle Co.....   | 13.13                  | 12.19                   | 4.15 | 12544    | 14590                                     |
| 1788        | Livingston Co..... | 12.73                  | 12.15                   | 3.67 | 12853    | 14929                                     |
| 1569a       | Macon Co.....      | 13.91                  | 11.33                   | 3.82 | 12549    | 14427                                     |
| 1874        | Macon Co.....      | 14.07                  | 11.82                   | 4.28 | 12545    | 14529                                     |
| 1749        | Mc Lean Co.....    | 12.56                  | 14.06                   | 4.74 | 12299    | 14672                                     |
| 1847        | Mc Lean Co.....    | 14.15                  | 13.54                   | 2.82 | 12485    | 14725                                     |
| 1848        | Menard Co.....     | 15.55                  | 12.20                   | 3.58 | 12590    | 14627                                     |
| 1403        | Peoria Co.....     | 14.29                  | 15.46                   | 3.16 | 12094    | 14635                                     |
| 1407        | Peoria Co.....     | 13.86                  | 16.25                   | 3.91 | 12044    | 14755                                     |
| 1408        | Peoria Co.....     | 13.91                  | 15.23                   | 3.39 | 12189    | 14713                                     |
| 1409        | Peoria Co.....     | 13.45                  | 16.66                   | 3.58 | 12014    | 14786                                     |
| 1410        | Peoria Co.....     | 14.73                  | 14.78                   | 3.97 | 12257    | 14730                                     |
| 540         | Sangamon Co.....   | 13.56                  | 10.76                   | 4.78 | 12749    | 14589                                     |
| 721         | Sangamon Co.....   | 14.39                  | 13.64                   | 4.61 | 12304    | 14593                                     |
| 740         | Sangamon Co.....   | 14.30                  | 12.75                   | 4.11 | 12369    | 14468                                     |
| 741         | Sangamon Co.....   | 13.13                  | 12.47                   | 4.28 | 12416    | 14495                                     |
| 1794        | Sangamon Co.....   | 13.69                  | 14.26                   | 3.88 | 12133    | 14477                                     |
| 1761        | Sangamon Co.....   | 14.61                  | 12.48                   | 4.55 | 12364    | 14444                                     |
| 1762        | Sangamon Co.....   | 14.56                  | 12.85                   | 4.54 | 12281    | 14415                                     |
| 1766        | Sangamon Co.....   | 15.42                  | 14.73                   | 4.19 | 12082    | 14515                                     |
| 1767        | Sangamon Co.....   | 15.53                  | 12.68                   | 3.83 | 12340    | 14427                                     |
| 1770        | Sangamon Co.....   | 14.89                  | 11.32                   | 4.79 | 12663    | 14591                                     |
| 1772        | Sangamon Co.....   | 14.00                  | 12.83                   | 4.06 | 12358    | 14486                                     |
| 1773        | Sangamon Co.....   | 14.44                  | 11.71                   | 4.85 | 12477    | 14447                                     |
| 1774        | Sangamon Co.....   | 14.41                  | 11.80                   | 5.09 | 12550    | 14557                                     |
| 1786        | Sangamon Co.....   | 14.18                  | 14.67                   | 5.00 | 12115    | 14574                                     |
| 1790        | Sangamon Co.....   | 16.41                  | 10.69                   | 3.65 | 12685    | 14477                                     |
| 1791        | Sangamon Co.....   | 15.44                  | 12.91                   | 4.01 | 12301    | 14430                                     |
| 1792        | Sangamon Co.....   | 15.38                  | 10.14                   | 4.00 | 12849    | 14578                                     |
| 1812        | Schuyler Co.....   | 12.99                  | 12.76                   | 4.31 | 12709    | 14899                                     |
| 1868        | Shelby Co.....     | 11.26                  | 13.63                   | 4.93 | 12373    | 14686                                     |
| 1412        | Tazewell Co.....   | 14.30                  | 11.49                   | 3.90 | 12690    | 14623                                     |
| 1413        | Tazewell Co.....   | 14.35                  | 12.45                   | 3.53 | 12504    | 14569                                     |
| 720         | Logan Co.....      | 14.80                  | 13.81                   | 3.56 | 12426    | 14733                                     |
| 1889        | Logan Co.....      | 11.83                  | 12.25                   | 3.83 | 12376    | 14392                                     |

TABLE 19  
BLUE BAND COAL

| Lab.<br>No. | LOCALITY           | Total<br>Moisture | REFERRED TO<br>DRY COAL |      |          | "Unit Coal"<br>Basis<br>B. t. u. — 5000 S.<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
|-------------|--------------------|-------------------|-------------------------|------|----------|-------------------------------------------------------------------------------------------------------|
|             |                    |                   | Ash                     | Sul. | B. t. u. |                                                                                                       |
| 742         | Christian Co.....  | 11.82             | 13.50                   | 4.71 | 12203    | 14448                                                                                                 |
| 1870        | Christian Co.....  | 15.15             | 9.97                    | 3.70 | 12745    | 14405                                                                                                 |
| 1871        | Christian Co.....  | 14.88             | 10.67                   | 4.04 | 12696    | 14484                                                                                                 |
| 996         | Clinton Co.....    | 10.97             | 10.47                   | 4.80 | 12815    | 14614                                                                                                 |
| 997         | Clinton Co.....    | 13.05             | 13.98                   | 5.29 | 12232    | 14596                                                                                                 |
| 1177        | Clinton Co.....    | 15.19             | 11.15                   | 1.65 | 12569    | 14342                                                                                                 |
| 1178        | Clinton Co.....    | 14.81             | 16.56                   | 2.99 | 11639    | 14262                                                                                                 |
| 1175        | Clinton Co.....    | 11.83             | 10.78                   | 3.96 | 12659    | 14459                                                                                                 |
| 1176        | Clinton Co.....    | 12.86             | 13.59                   | 4.52 | 12246    | 14512                                                                                                 |
| 1845        | Edgar Co.....      | 14.94             | 11.00                   | 3.02 | 12890    | 14734                                                                                                 |
| 1846        | Edgar Co.....      | 14.82             | 11.42                   | 3.34 | 12797    | 14715                                                                                                 |
| 461         | Franklin Co.....   | 14.40             | 8.08                    | 1.19 | 13400    | 14722                                                                                                 |
| 419         | Franklin Co.....   | 11.19             | 10.11                   | .60  | 12985    | 14597                                                                                                 |
| 420         | Franklin Co.....   | 10.06             | 7.53                    | .91  | 13312    | 14519                                                                                                 |
| 1810        | Franklin Co.....   | 10.13             | 10.29                   | .78  | 12945    | 14590                                                                                                 |
| 1722        | Franklin Co.....   | 8.47              | 10.55                   | 2.13 | 12778    | 14491                                                                                                 |
| 1723        | Franklin Co.....   | 9.09              | 8.78                    | 1.21 | 13173    | 14595                                                                                                 |
| 1776        | Franklin Co.....   | 9.11              | 6.42                    | 1.33 | 13620    | 14679                                                                                                 |
| 1777        | Franklin Co.....   | 8.48              | 7.32                    | 1.33 | 13527    | 14734                                                                                                 |
| 1799        | Jackson Co.....    | 7.81              | 13.20                   | 3.85 | 12650    | 14897                                                                                                 |
| 1800        | Jackson Co.....    | 9.14              | 10.22                   | .68  | 12970    | 14603                                                                                                 |
| 1651        | Jefferson Co.....  | 7.48              | 11.35                   | 3.34 | 12824    | 14735                                                                                                 |
| 1652        | Jefferson Co.....  | 7.85              | 12.10                   | 4.19 | 12611    | 14655                                                                                                 |
| 735         | Macoupin Co.....   | 12.80             | 10.86                   | 5.38 | 12469    | 14301                                                                                                 |
| 736         | Macoupin Co.....   | 12.71             | 11.40                   | 4.41 | 12360    | 14238                                                                                                 |
| 737         | Macoupin Co.....   | 12.17             | 12.87                   | 5.48 | 12303    | 14477                                                                                                 |
| 738         | Macoupin Co.....   | 12.80             | 11.90                   | 4.33 | 12440    | 14419                                                                                                 |
| 1841        | Macoupin Co.....   | 12.89             | 12.68                   | 6.49 | 12214    | 14369                                                                                                 |
| 1862        | Macoupin Co.....   | 13.93             | 12.29                   | 5.23 | 12371    | 14441                                                                                                 |
| 725         | Madison Co.....    | 11.68             | 11.22                   | 4.85 | 12762    | 14692                                                                                                 |
| 1117        | Madison Co.....    | 10.33             | 10.59                   | 4.12 | 12681    | 14457                                                                                                 |
| 1118        | Madison Co.....    | 14.16             | 13.65                   | 2.81 | 12114    | 14303                                                                                                 |
| 1119        | Madison Co.....    | 11.20             | 11.72                   | 5.17 | 12499    | 14485                                                                                                 |
| 1866        | Marion Co.....     | 10.31             | 14.96                   | 5.61 | 12167    | 14720                                                                                                 |
| 1842        | Montgomery Co..... | 13.61             | 8.50                    | 4.37 | 13473    | 14990                                                                                                 |
| 1864        | Montgomery Co..... | 12.84             | 10.58                   | 4.30 | 12743    | 14534                                                                                                 |
| 1863        | Montgomery Co..... | 14.76             | 9.98                    | 4.60 | 12712    | 14398                                                                                                 |
| 1873        | Montgomery Co..... | 13.21             | 11.51                   | 4.90 | 12570    | 14522                                                                                                 |
| 421         | Perry Co.....      | 9.31              | 14.71                   | .98  | 12181    | 14517                                                                                                 |
| 1523        | Perry Co.....      | 11.03             | 12.63                   | 1.01 | 12453    | 14456                                                                                                 |
| 1614        | Perry Co.....      | 10.37             | 13.92                   | 3.93 | 12293    | 14607                                                                                                 |
| 1615        | Perry Co.....      | 9.87              | 13.86                   | 3.28 | 12261    | 14534                                                                                                 |
| 1591        | Perry Co.....      | 11.11             | 15.89                   | 4.34 | 11859    | 14471                                                                                                 |
| 1592        | Perry Co.....      | 10.49             | 12.17                   | 3.84 | 12361    | 14359                                                                                                 |
| 1835        | Perry Co.....      | 10.55             | 12.12                   | 4.50 | 12393    | 14412                                                                                                 |
| 1610        | Randolph Co.....   | 10.72             | 14.55                   | 5.07 | 11978    | 14385                                                                                                 |

TABLE 19  
BLUE BAND COAL—(Concluded)

| Lab.<br>No. | LOCALITY           | Total<br>Mois-<br>ture | REFERRED TO<br>DRY COAL |      |          | "Unit Coal"<br>Basis<br>B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |
|-------------|--------------------|------------------------|-------------------------|------|----------|----------------------------------------------------------------------------------------|
|             |                    |                        | Ash                     | Sul. | B. t. u. |                                                                                        |
| 1616        | Randolph Co.....   | 9.93                   | 13.41                   | 5.36 | 12245    | 14505                                                                                  |
| 1120        | Saline Co.....     | 5.98                   | 13.79                   | 3.73 | 12505    | 14830                                                                                  |
| 722         | Sangamon Co.....   | 14.96                  | 11.04                   | 4.55 | 12640    | 14503                                                                                  |
| 1763        | Sangamon Co.....   | 14.69                  | 10.98                   | 4.95 | 12503    | 14349                                                                                  |
| 739         | Sangamon Co.....   | 13.14                  | 12.23                   | 5.03 | 12372    | 14425                                                                                  |
| 723         | St. Clair Co.....  | 12.11                  | 12.23                   | 4.37 | 12604    | 14676                                                                                  |
| 724         | St. Clair Co.....  | 12.23                  | 9.69                    | 3.33 | 12982    | 14612                                                                                  |
| 991         | St. Clair Co.....  | 9.76                   | 15.80                   | 4.76 | 12202    | 14895                                                                                  |
| 995         | St. Clair Co.....  | 10.05                  | 12.47                   | 4.19 | 12587    | 14694                                                                                  |
| 993         | St. Clair Co.....  | 9.44                   | 11.23                   | 4.37 | 12723    | 14630                                                                                  |
| 1001        | St. Clair Co.....  | 13.75                  | 12.53                   | 2.13 | 12486    | 14512                                                                                  |
| 1002        | St. Clair Co.....  | 13.15                  | 13.43                   | 3.23 | 12290    | 14486                                                                                  |
| 1003        | St. Clair Co.....  | 9.41                   | 12.94                   | 4.90 | 12701    | 14948                                                                                  |
| 1129        | St. Clair Co.....  | 15.91                  | 11.07                   | 4.70 | 12706    | 14593                                                                                  |
| 1130        | St. Clair Co.....  | 11.11                  | 12.00                   | 4.72 | 12587    | 14625                                                                                  |
| 1174        | St. Clair Co.....  | 15.46                  | 12.73                   | 4.02 | 12428    | 14549                                                                                  |
| 1600        | St. Clair Co.....  | 11.43                  | 15.14                   | 5.69 | 11908    | 14435                                                                                  |
| 557         | Vermilion Co.....  | 12.56                  | 9.15                    | 1.41 | 13058    | 14537                                                                                  |
| 558         | Vermilion Co.....  | 12.96                  | 8.03                    | 1.78 | 13304    | 14626                                                                                  |
| 1540        | Vermilion Co.....  | 17.73                  | 11.95                   | 1.15 | 12561    | 14463                                                                                  |
| 1843        | Vermilion Co.....  | 13.23                  | 11.43                   | 3.17 | 12842    | 14761                                                                                  |
| 1844        | Vermilion Co.....  | 13.41                  | 9.76                    | 3.52 | 13083    | 14748                                                                                  |
| 1643        | Washington Co..... | 10.41                  | 11.34                   | 4.35 | 12468    | 14351                                                                                  |
| 1121        | White Co.....      | 6.71                   | 11.50                   | 4.46 | 12744    | 14708                                                                                  |
| 459         | Williamson Co..... | 9.99                   | 8.48                    | 1.03 | 13323    | 14701                                                                                  |
| 460         | Williamson Co..... | 9.50                   | 10.13                   | 1.12 | 13078    | 14724                                                                                  |
| 1088        | Williamson Co..... | 6.69                   | 10.65                   | 2.50 | 13016    | 14795                                                                                  |
| 462         | Williamson Co..... | 9.39                   | 7.66                    | 1.89 | 13475    | 14754                                                                                  |
| 1611        | Williamson Co..... | 10.15                  | 9.73                    | 1.06 | 13229    | 14763                                                                                  |
| 1612        | Williamson Co..... | 6.12                   | 13.76                   | 4.42 | 12461    | 14799                                                                                  |
| 1567        | Williamson Co..... | 6.80                   | 11.84                   | 2.96 | 12788    | 14770                                                                                  |
| 1613        | Williamson Co..... | 9.69                   | 10.23                   | 1.16 | 13077    | 14742                                                                                  |
| 1801        | Williamson Co..... | 9.75                   | 8.13                    | 1.71 | 13438    | 14791                                                                                  |
| 1805        | Williamson Co..... | 7.58                   | 12.10                   | 3.85 | 12698    | 14745                                                                                  |
| 1806        | Williamson Co..... | 9.79                   | 9.85                    | 2.19 | 13048    | 14676                                                                                  |
| 1804        | Williamson Co..... | 6.77                   | 13.29                   | 5.08 | 12517    | 14800                                                                                  |
| 1917        | Williamson Co..... | 8.86                   | 9.65                    | 1.15 | 13103    | 14685                                                                                  |
| 1918        | Williamson Co..... | 9.34                   | 9.50                    | 1.74 | 13172    | 14739                                                                                  |





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## APPENDIX A

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TABLE 20  
UNIT COAL VALUES

Compiled from Bulletin 9, Fourth Series, 1908, Ohio State Geological Survey

| No.                            | COUNTY          | ANALYSES OF COAL<br>AS RECEIVED |       |              |          | "Unit Coal"<br>Basis                                           |
|--------------------------------|-----------------|---------------------------------|-------|--------------|----------|----------------------------------------------------------------|
|                                |                 | Mois-<br>ture                   | Ash   | Sul-<br>phur | B. t. u. |                                                                |
|                                |                 |                                 |       |              |          | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |
| CLARION OR NO. 4 COAL          |                 |                                 |       |              |          |                                                                |
| 65                             | Lawrence.....   | 6.34                            | 17.41 | 5.29         | 10741    | 14562                                                          |
| 67                             | Lawrence.....   | 5.86                            | 15.28 | 5.36         | 11133    | 14547                                                          |
| 68                             | Lawrence.....   | 6.11                            | 9.94  | 3.61         | 11957    | 14508                                                          |
| 66                             | Lawrence.....   | 6.00                            | 11.86 | 5.10         | 11734    | 14645                                                          |
| 64                             | Scioto.....     | 6.80                            | 9.34  | 3.45         | 11763    | 14272                                                          |
| 63                             | Jackson.....    | 4.90                            | 13.70 | 6.14         | 11495    | 14545                                                          |
| 62                             | Jackson.....    | 5.31                            | 13.54 | 6.08         | 11381    | 14436                                                          |
| 55                             | Jackson.....    | 5.61                            | 8.09  | 3.70         | 12279    | 14465                                                          |
| 56                             | Jackson.....    | 4.98                            | 9.80  | 4.08         | 12154    | 14538                                                          |
| 57                             | Jackson.....    | 4.71                            | 8.61  | 3.73         | 12361    | 14505                                                          |
| 60                             | Jackson.....    | 5.33                            | 8.40  | 3.72         | 12206    | 14387                                                          |
| 59                             | Vinton.....     | 4.72                            | 11.21 | 4.16         | 12049    | 14640                                                          |
| 61                             | Vinton.....     | 4.52                            | 8.85  | 4.23         | 12337    | 14505                                                          |
| 54                             | Vinton.....     | 5.02                            | 8.15  | 2.81         | 12469    | 14639                                                          |
| 58                             | Vinton.....     | 4.61                            | 11.10 | 5.28         | 12053    | 14645                                                          |
| 70                             | Vinton.....     | 5.02                            | 8.97  | 3.32         | 12528    | 14780                                                          |
| 69                             | Vinton.....     | 4.95                            | 9.32  | 3.53         | 12445    | 14775                                                          |
|                                | Average.....    | 5.34                            | 10.80 | 4.33         | 11947    | 14551                                                          |
| LOWER KITTANING OR NO. 5 COAL  |                 |                                 |       |              |          |                                                                |
| 74                             | Lawrence.....   | 7.57                            | 8.79  | 3.20         | 12199    | 14830                                                          |
| 75                             | Lawrence.....   | 8.07                            | 9.71  | 2.13         | 11927    | 14727                                                          |
| 76                             | Jackson.....    | 8.39                            | 7.42  | 2.65         | 12190    | 14679                                                          |
| 71                             | Perry.....      | 6.85                            | 10.16 | 4.72         | 11864    | 14612                                                          |
| 72                             | Perry.....      | 6.74                            | 7.12  | 2.58         | 12393    | 14574                                                          |
| 73                             | Muskingum.....  | 5.05                            | 7.77  | 4.80         | 12569    | 14691                                                          |
| 77b                            | Jefferson.....  | 2.46                            | 7.40  | 3.82         | 13664    | 15406                                                          |
| 77                             | Tuscarawas..... | 5.30                            | 7.71  | 3.25         | 12902    | 15061                                                          |
| 77a                            | Mahoning.....   | 5.23                            | 4.72  | 2.17         | 13504    | 15141                                                          |
|                                | Av.....         | 6.18                            | 7.87  | 3.26         | 12578    | 14863                                                          |
| MIDDLE KITTANING OR NO. 6 COAL |                 |                                 |       |              |          |                                                                |
| 136                            | Lawrence.....   | 5.99                            | 4.82  | 3.61         | 13165    | 14957                                                          |
| 82a                            | Lawrence.....   | 6.64                            | 10.92 | 3.32         | 11927    | 14749                                                          |
| 82b                            | Gallia.....     | 8.08                            | 8.52  | 3.64         | 12091    | 14753                                                          |
| 89a                            | Athens.....     | 6.36                            | 8.49  | 0.51         | 12454    | 14764                                                          |
| 83                             | Athens.....     | 6.17                            | 7.82  | 0.90         | 12362    | 14511                                                          |
| 84                             | Athens.....     | 6.70                            | 6.75  | 2.28         | 12458    | 14563                                                          |

TABLE 20  
UNIT COAL VALUES—(Continued)

| No. | COUNTY          | ANALYSES OF COAL<br>AS RECEIVED |       |         |          | "Unit Coal"<br>Basis                                           |
|-----|-----------------|---------------------------------|-------|---------|----------|----------------------------------------------------------------|
|     |                 | Moisture                        | Ash   | Sulphur | B. t. u. |                                                                |
|     |                 |                                 |       |         |          | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |
| 85  | Athens.....     | 6.80                            | 8.05  | 2.14    | 12229    | 14547                                                          |
| 82  | Vinton.....     | 4.90                            | 10.15 | 4.25    | 12321    | 14802                                                          |
| 81  | Hocking.....    | 6.52                            | 8.03  | 3.52    | 12330    | 14666                                                          |
| 89  | Athens.....     | 7.14                            | 6.72  | 1.65    | 12353    | 14488                                                          |
| 90  | Athens.....     | 7.28                            | 6.73  | 0.86    | 12409    | 14552                                                          |
| 86  | Hocking.....    | 7.55                            | 5.85  | 0.77    | 12510    | 14552                                                          |
| 87  | Hocking.....    | 7.45                            | 4.81  | 0.66    | 12703    | 14563                                                          |
| 88  | Hocking.....    | 7.40                            | 5.00  | 1.06    | 12649    | 14542                                                          |
| 80  | Hocking.....    | 6.55                            | 6.97  | 2.57    | 12422    | 14548                                                          |
| 79  | Perry.....      | 7.76                            | 7.47  | 1.45    | 12190    | 14534                                                          |
| 91  | Perry.....      | 5.79                            | 5.91  | 1.00    | 12569    | 14510                                                          |
| 78  | Perry.....      | 7.00                            | 6.95  | 2.33    | 12384    | 14569                                                          |
| 92  | Perry.....      | 5.25                            | 9.86  | 3.43    | 12191    | 14620                                                          |
| 93  | Perry.....      | 5.90                            | 10.10 | 4.96    | 12035    | 14649                                                          |
| 95  | Perry.....      | 6.72                            | 6.64  | 2.43    | 12425    | 14513                                                          |
| 94  | Perry.....      | 7.21                            | 5.26  | 2.34    | 12614    | 14562                                                          |
| 97  | Perry.....      | 5.70                            | 8.45  | 3.38    | 12332    | 14600                                                          |
| 98  | Perry.....      | 6.40                            | 7.58  | 2.72    | 12361    | 14569                                                          |
| 101 | Muskingum.....  | 5.08                            | 9.77  | 5.54    | 12244    | 14716                                                          |
| 100 | Muskingum.....  | 4.67                            | 9.83  | 4.10    | 12371    | 14756                                                          |
| 96  | Muskingum.....  | 5.02                            | 9.56  | 5.97    | 12164    | 14581                                                          |
| 99  | Muskingum.....  | 5.44                            | 9.28  | 3.77    | 12280    | 14663                                                          |
| 104 | Muskingum.....  | 5.55                            | 5.23  | 3.63    | 12944    | 14703                                                          |
| 102 | Muskingum.....  | 4.75                            | 9.28  | 5.35    | 12337    | 14668                                                          |
| 103 | Muskingum.....  | 4.62                            | 6.58  | 4.49    | 12827    | 14689                                                          |
| 111 | Coshocton.....  | 4.37                            | 5.36  | 3.61    | 13045    | 14643                                                          |
| 112 | Coshocton.....  | 10.93                           | 6.64  | 2.03    | 11039    | 13871*                                                         |
| 108 | Coshocton.....  | 4.33                            | 5.59  | 4.00    | 13084    | 14736                                                          |
| 109 | Coshocton.....  | 5.12                            | 7.02  | 3.87    | 12719    | 14708                                                          |
| 105 | Coshocton.....  | 5.32                            | 6.30  | 4.22    | 12755    | 14661                                                          |
| 110 | Coshocton.....  | 5.60                            | 13.28 | 4.87    | 11200    | 14159                                                          |
| 113 | Coshocton.....  | 4.44                            | 4.45  | 3.54    | 13232    | 14702                                                          |
| 114 | Coshocton.....  | 4.58                            | 8.75  | 5.36    | 12380    | 14589                                                          |
| 118 | Coshocton.....  | 5.32                            | 8.60  | 4.36    | 12290    | 14546                                                          |
| 120 | Coshocton.....  | 4.50                            | 5.97  | 3.63    | 12911    | 14623                                                          |
| 107 | Coshocton.....  | 5.40                            | 5.08  | 3.18    | 12949    | 14641                                                          |
| 133 | Tuscarawas..... | 3.45                            | 7.67  | 5.22    | 12843    | 14733                                                          |
| 131 | Tuscarawas..... | 3.41                            | 9.38  | 4.88    | 12548    | 14686                                                          |
| 115 | Tuscarawas..... | 4.72                            | 5.47  | 4.05    | 12958    | 14637                                                          |
| 130 | Tuscarawas..... | 3.78                            | 8.42  | 3.83    | 12782    | 14808                                                          |
| 129 | Tuscarawas..... | 3.81                            | 6.01  | 3.24    | 13151    | 14774                                                          |
| 124 | Tuscarawas..... | 4.10                            | 5.21  | 3.25    | 13196    | 14730                                                          |
| 134 | Tuscarawas..... | 3.18                            | 6.93  | 4.12    | 13149    | 14865                                                          |
| 116 | Tuscarawas..... | 5.19                            | 5.87  | 3.55    | 12820    | 14613                                                          |
| 128 | Tuscarawas..... | 4.30                            | 7.63  | 3.97    | 12602    | 14546                                                          |

\* Low B. t. u. due to weathering.

TABLE 20  
UNIT COAL VALUES—(Continued)

| No.     | COUNTY          | ANALYSES OF COAL<br>AS RECEIVED |       |              |          | "Unit Coal"<br>Basis                                                         |
|---------|-----------------|---------------------------------|-------|--------------|----------|------------------------------------------------------------------------------|
|         |                 | Mois-<br>ture                   | Ash   | Sul-<br>phur | B. t. u. | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| 117     | Coshocton.....  | 4.70                            | 11.29 | 5.60         | 11869    | 14481                                                                        |
| 106     | Coshocton.....  | 5.30                            | 6.15  | 3.72         | 12751    | 14609                                                                        |
| 121     | Tuscarawas..... | 3.52                            | 6.01  | 3.17         | 13135    | 14705                                                                        |
| 122     | Tuscarawas..... | 4.94                            | 9.50  | 4.19         | 12341    | 14706                                                                        |
| 123     | Tuscarawas..... | 3.51                            | 7.69  | 4.56         | 12875    | 14761                                                                        |
| 132     | Carroll.....    | 3.76                            | 6.79  | 3.06         | 13028    | 14760                                                                        |
| 138     | Tuscarawas..... | 7.15                            | 4.56  | 2.62         | 12949    | 14820                                                                        |
| 127     | Tuscarawas..... | 4.66                            | 6.22  | 3.28         | 12775    | 14525                                                                        |
| 119     | Holmes.....     | 7.31                            | 4.21  | 1.00         | 12514    | 14230                                                                        |
| 125     | Tuscarawas..... | 4.69                            | 9.06  | 4.70         | 12386    | 14649                                                                        |
| 126     | Tuscarawas..... | 4.92                            | 7.04  | 2.91         | 12748    | 14676                                                                        |
| 135     | Stark.....      | 6.66                            | 8.22  | 2.66         | 12559    | 14971                                                                        |
| 137     | Columbiana..... | 3.60                            | 4.60  | 1.76         | 14020    | 15401                                                                        |
| 139     | Stark.....      | 5.65                            | 10.08 | 4.13         | 12362    | 14973                                                                        |
| Av..... |                 | 5.56                            | 7.36  | 3.30         | 12564    | 14644                                                                        |

## UPPER FREEPORT, WATERLOO OR NO. 7 COAL

|         |               |      |       |      |       |       |
|---------|---------------|------|-------|------|-------|-------|
| 147     | Lawrence..... | 7.20 | 10.67 | 2.33 | 11801 | 14824 |
| 144     | Lawrence..... | 7.85 | 12.18 | 2.66 | 11349 | 14465 |
| 145     | Lawrence..... | 8.37 | 8.23  | 1.29 | 11873 | 14396 |
| 146     | Lawrence..... | 8.45 | 11.28 | 0.93 | 11529 | 14547 |
| 142     | Gallia.....   | 7.62 | 12.39 | 1.81 | 11468 | 14586 |
| 140     | Lawrence..... | 7.13 | 8.91  | 1.31 | 12089 | 14570 |
| 141     | Lawrence..... | 8.77 | 8.71  | 0.76 | 11855 | 14517 |
| 143     | Lawrence..... | 8.38 | 10.09 | 1.84 | 11695 | 14556 |
| Av..... |               | 7.97 | 10.31 | 1.62 | 11707 | 14531 |

## UPPER FREEPORT OR NO. 7 COAL

|         |                |      |       |      |       |       |
|---------|----------------|------|-------|------|-------|-------|
| 148     | Muskingum..... | 4.89 | 7.78  | 4.36 | 12499 | 14566 |
| 149     | Muskingum..... | 4.72 | 7.56  | 5.00 | 12683 | 14736 |
| 150     | Muskingum..... | 5.11 | 12.60 | 3.84 | 11804 | 14667 |
| 151     | Coshocton..... | 6.40 | 3.19  | 2.01 | 13185 | 14694 |
| Av..... |                | 5.28 | 7.78  | 3.80 | 12542 | 14665 |



TABLE 20  
UNIT COAL VALUES—(Continued)

| No.                     | COUNTY         | ANALYSES OF COAL<br>AS RECEIVED |       |              |          | "Unit Coal"<br>Basis                                    |
|-------------------------|----------------|---------------------------------|-------|--------------|----------|---------------------------------------------------------|
|                         |                | Mois-<br>ture                   | Ash   | Sul-<br>phur | B. t. u. | B. t. u. — 5000 S                                       |
|                         |                |                                 |       |              |          | 1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| PITTSBURG OR No. 8 COAL |                |                                 |       |              |          |                                                         |
| 25                      | Gallia.....    | 5.80                            | 10.06 | 4.34         | 11792    | 14301                                                   |
| 27                      | Gallia.....    | 6.98                            | 9.03  | 5.21         | 11849    | 14413                                                   |
| 28                      | Gallia.....    | 7.83                            | 9.76  | 3.89         | 11779    | 14575                                                   |
| 26                      | Gallia.....    | 6.73                            | 13.03 | 4.37         | 11441    | 14614                                                   |
| 23                      | Athens.....    | 5.78                            | 8.00  | 4.19         | 12299    | 14618                                                   |
| 24                      | Athens.....    | 6.60                            | 10.20 | 3.41         | 11892    | 14560                                                   |
| 24                      | Athens.....    | 4.51                            | 11.49 | 4.88         | 11945    | 14553                                                   |
| 22                      | Morgan.....    | 6.87                            | 8.19  | 4.22         | 12100    | 14504                                                   |
| 9                       | Belmont.....   | 2.79                            | 9.42  | 5.09         | 12987    | 14134                                                   |
| 11                      | Belmont.....   | 4.08                            | 10.61 | 4.95         | 12476    | 14961                                                   |
| 8                       | Belmont.....   | 2.91                            | 8.00  | 4.31         | 13212    | 15099                                                   |
| 3                       | Belmont.....   | 3.51                            | 6.86  | 3.76         | 13185    | 14937                                                   |
| 4                       | Belmont.....   | 3.80                            | 8.95  | 4.27         | 12785    | 14933                                                   |
| 7                       | Belmont.....   | 3.21                            | 7.26  | 4.28         | 13135    | 14920                                                   |
| 10                      | Belmont.....   | 4.47                            | 11.01 | 4.67         | 12375    | 14976                                                   |
| 6                       | Belmont.....   | 3.75                            | 10.84 | 4.76         | 12357    | 14794                                                   |
| 5                       | Belmont.....   | 4.46                            | 10.76 | 4.45         | 12425    | 14977                                                   |
| 1                       | Belmont.....   | 3.39                            | 7.86  | 2.97         | 12991    | 14850                                                   |
| 2                       | Belmont.....   | 3.79                            | 9.00  | 4.16         | 12861    | 15027                                                   |
| 6a                      | Belmont.....   | 4.25                            | 10.35 | 3.95         | 12425    | 14840                                                   |
| 2a                      | Belmont.....   | 4.23                            | 9.21  | 4.17         | 12605    | 14842                                                   |
| 12                      | Jefferson..... | 3.10                            | 9.52  | 3.83         | 12875    | 15008                                                   |
| 15                      | Jefferson..... | 3.13                            | 8.22  | 4.02         | 13019    | 14943                                                   |
| 15a                     | Jefferson..... | 4.57                            | 9.00  | 1.55         | 12789    | 14980                                                   |
| 18                      | Harrison.....  | 6.54                            | 6.74  | 2.19         | 12710    | 14829                                                   |
| 21                      | Harrison.....  | 5.98                            | 5.97  | 1.35         | 12964    | 14853                                                   |
| 20                      | Harrison.....  | 3.83                            | 10.88 | 4.38         | 12355    | 14798                                                   |
| 16                      | Jefferson..... | 4.89                            | 10.46 | 4.09         | 12515    | 15095                                                   |
| 13                      | Jefferson..... | 4.96                            | 6.45  | 1.75         | 13099    | 14938                                                   |
| 19                      | Jefferson..... | 4.18                            | 8.22  | 2.83         | 12888    | 14928                                                   |
| 14                      | Jefferson..... | 4.30                            | 7.88  | 3.01         | 12859    | 14858                                                   |
| 17                      | Jefferson..... | 5.05                            | 7.95  | 2.61         | 12865    | 14995                                                   |
| Av.....                 |                | 4.70                            | 9.10  | 3.81         | 12559    | 14835                                                   |
| POMEROY OR No. 8a COAL  |                |                                 |       |              |          |                                                         |
| 34                      | Gallia.....    | 8.21                            | 11.46 | 2.18         | 11497    | 14561                                                   |
| 33                      | Meigs.....     | 4.85                            | 12.52 | 2.94         | 11923    | 14718                                                   |
| 29                      | Meigs.....     | 7.33                            | 8.69  | 2.05         | 12105    | 14608                                                   |
| 30                      | Meigs.....     | 7.22                            | 9.29  | 1.32         | 12002    | 14552                                                   |
| 31                      | Meigs.....     | 5.51                            | 10.58 | 4.17         | 11990    | 14588                                                   |
| 32                      | Meigs.....     | 7.63                            | 10.93 | 1.83         | 11722    | 14618                                                   |
| Av.....                 |                | 6.79                            | 10.58 | 2.42         | 11873    | 14608                                                   |

TABLE 20  
UNIT COAL VALUES—(Concluded)

| No.                       | COUNTY          | ANALYSES OF COAL<br>AS RECEIVED |       |              |          | "Unit Coal"<br>Basis                                                          |
|---------------------------|-----------------|---------------------------------|-------|--------------|----------|-------------------------------------------------------------------------------|
|                           |                 | Mois-<br>ture                   | Ash   | Sul-<br>phur | B. t. u. | B. t. u. — 5000 S.<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| MEIGS CREEK OR No. 9 COAL |                 |                                 |       |              |          |                                                                               |
| 53                        | Washington..... | 2.95                            | 12.89 | 5.55         | 12245    | 14946                                                                         |
| 52                        | Washington..... | 3.40                            | 9.58  | 5.03         | 12749    | 14970                                                                         |
| 44                        | Noble.....      | 3.06                            | 12.33 | 6.00         | 12357    | 15011                                                                         |
| 45                        | Noble.....      | 2.90                            | 10.16 | 4.27         | 12692    | 14895                                                                         |
| 43                        | Noble.....      | 2.55                            | 11.41 | 5.79         | 12514    | 14918                                                                         |
| 42                        | Noble.....      | 3.12                            | 12.85 | 5.60         | 12130    | 14827                                                                         |
| 50                        | Morgan.....     | 5.13                            | 11.74 | 4.89         | 11925    | 15270                                                                         |
| 48                        | Morgan.....     | 5.05                            | 10.37 | 4.30         | 12114    | 14621                                                                         |
| 49                        | Morgan.....     | 4.07                            | 10.66 | 5.07         | 12202    | 14637                                                                         |
| 47                        | Noble.....      | 3.54                            | 13.23 | 6.21         | 11956    | 14787                                                                         |
| 46                        | Noble.....      | 4.85                            | 9.82  | 5.59         | 12301    | 14757                                                                         |
| 37                        | Belmont.....    | 4.47                            | 13.07 | 3.27         | 12002    | 14870                                                                         |
| 40                        | Belmont.....    | 3.40                            | 14.94 | 4.39         | 11840    | 14890                                                                         |
| 41                        | Belmont.....    | 3.52                            | 11.84 | 3.67         | 12391    | 14947                                                                         |
| 39                        | Belmont.....    | 4.17                            | 9.60  | 3.11         | 12602    | 14863                                                                         |
| 38                        | Belmont.....    | 4.31                            | 11.68 | 1.94         | 12307    | 14888                                                                         |
| 36a                       | Belmont.....    | 7.52                            | 11.24 | 2.11         | 11860    | 14846                                                                         |
| 36                        | Belmont.....    | 4.98                            | 12.82 | 2.41         | 11974    | 14846                                                                         |
| 35                        | Harrison.....   | 5.35                            | 10.29 | 2.20         | 12393    | 14919                                                                         |
|                           | Av.....         | 4.11                            | 11.60 | 4.28         | 12240    | 14845                                                                         |

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## APPENDIX B

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TABLE 21

## UNIT COAL VALUES

Compiled from Bulletins 261, 290, 332, United States  
Geological Survey

| State No. | Table No. | COUNTY         | ANALYSES OF COAL<br>AS RECEIVED |       |              |          | "Unit Coal"<br>Basis                                                         |
|-----------|-----------|----------------|---------------------------------|-------|--------------|----------|------------------------------------------------------------------------------|
|           |           |                | Mois-<br>ture                   | Ash   | Sul-<br>phur | B. t. u. |                                                                              |
|           |           |                |                                 |       |              |          | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| ALABAMA   |           |                |                                 |       |              |          |                                                                              |
| 1         | 1078M*    | Walker.....    | 1.35                            | 13.63 | .71          | 12991    | 15509                                                                        |
| 1         | 1201C *   | Walker.....    | 2.34                            | 12.54 | .72          | 12856    | 15313                                                                        |
| 2         | 1075M     | Walker.....    | 2.25                            | 9.04  | 1.09         | 13133    | 14967                                                                        |
| 2         | 1076M     | Walker.....    | 2.42                            | 11.13 | 1.10         | 12695    | 14879                                                                        |
| 2         | 3011M     | Walker.....    | 4.71                            | 10.17 | 1.33         | 12596    | 14992                                                                        |
| 2         | 1225C     | Walker.....    | 3.36                            | 12.43 | 1.01         | 12350    | 14879                                                                        |
| 2         | 3211C     | Walker.....    | 3.95                            | 14.59 | 1.12         | 11785    | 14722                                                                        |
| 3         | 3018M     | Bibb.....      | 3.03                            | 10.72 | .49          | 13034    | 15285                                                                        |
| 3         | 3255C     | Bibb.....      | 2.72                            | 14.36 | .55          | 12461    | 15263                                                                        |
| 4         | 3034M     | Bibb.....      | 3.67                            | 3.14  | 1.22         | 14396    | 15536                                                                        |
| 4         | 3103C     | Bibb.....      | 6.43                            | 12.92 | 1.08         | 12395    | 15616                                                                        |
| 5         | 4091M     | Blount.....    | 2.93                            | 2.73  | .65          | 14693    | 15636                                                                        |
| 5         | 4252C     | Blount.....    | 5.59                            | 16.08 | 1.40         | 11906    | 15518                                                                        |
| 6         | 4293M     | Jefferson..... | 2.81                            | 3.51  | .59          | 14643    | 15701                                                                        |
| 5         | 4338C     | Jefferson..... | 3.23                            | 6.71  | .61          | 14074    | 15747                                                                        |
| ARKANSAS  |           |                |                                 |       |              |          |                                                                              |
| 1         | 1045M     | Sebastian..... | 1.02                            | 7.49  | 1.10         | 14434    | 15927                                                                        |
| 1         | 2585M     | Sebastian..... | 3.53                            | 7.77  | 1.29         | 14017    | 15971                                                                        |
| 1         | 1114C     | Sebastian..... | 3.24                            | 12.61 | 1.24         | 13129    | 15846                                                                        |
| 1         | 2689C     | Sebastian..... | 7.49                            | 17.97 | 1.06         | 11369    | 15604                                                                        |
| 2         | 1049M     | Sebastian..... | .95                             | 6.97  | 2.12         | 14387    | 15806                                                                        |
| 2         | 1160C     | Sebastian..... | 2.23                            | 9.20  | 1.87         | 13750    | 15733                                                                        |
| 3         | 1115M     | Sebastian..... | 1.60                            | 7.91  | 1.42         | 14162    | 15818                                                                        |
| 3         | 1296C     | Sebastian..... | 2.19                            | 11.63 | 1.28         | 13464    | 15849                                                                        |
| 5         | 1130M     | Franklin.....  | 1.38                            | 6.95  | 1.52         | 14330    | 15790                                                                        |
| 5         | 1331C     | Franklin.....  | 2.36                            | 12.08 | 1.99         | 13259    | 15761                                                                        |
| 7         | 2593M     | Sebastian..... | 3.97                            | 5.91  | 1.53         | 14236    | 15945                                                                        |
| 7         | 2688C     | Sebastian..... | 5.47                            | 11.69 | 2.02         | 12690    | 15582                                                                        |
| 7         | 2722C     | Sebastian..... | 6.89                            | 15.00 | 2.24         | 12060    | 15787                                                                        |
| 8         | 2587M     | Johnson.....   | 3.12                            | 8.46  | 1.84         | 13793    | 15797                                                                        |
| 8         | 2744C     | Johnson.....   | 5.19                            | 14.01 | 2.05         | 12460    | 15731                                                                        |
| 9         | 2599M     | Sebastian..... | 1.99                            | 7.06  | 1.05         | 14087    | 15628                                                                        |
| 9         | 2690C     | Sebastian..... | 5.26                            | 24.81 | 1.00         | 10451    | 15434                                                                        |
| 10        | 2647M     | Ouachita.....  | 39.50                           | 12.58 | .53          | 5877     | 12551                                                                        |
| 10        | 2726C     | Ouachita.....  | 39.43                           | 9.71  | .49          | 6356     | 12717                                                                        |
| 13        | 3798M     | Franklin.....  | 2.91                            | 17.51 | 3.12         | 12312    | 15898                                                                        |
| 13        | 4626C     | Franklin.....  | 1.76                            | 14.96 | 2.29         | 12926    | 15853                                                                        |

\* Samples marked M are mine samples: those marked C are car samples of various sizes of coal.



TABLE 21  
UNIT COAL VALUES—(Continued)

| State No.  | Table No. | COUNTY         | ANALYSES OF COAL AS RECEIVED |       |              |          | "Unit Coal" Basis                                                            |
|------------|-----------|----------------|------------------------------|-------|--------------|----------|------------------------------------------------------------------------------|
|            |           |                | Mois-<br>ture                | Ash   | Sul-<br>phur | B. t. u. |                                                                              |
|            |           |                |                              |       |              |          | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| CALIFORNIA |           |                |                              |       |              |          |                                                                              |
| 1          | 1607M     | Alameda.....   | 18.02                        | 16.37 | 3.07         | 8105     | 12699                                                                        |
| 1          | 1680C     | Alameda.....   | 18.51                        | 15.49 | 3.05         | 8507     | 13243                                                                        |
| COLORADO   |           |                |                              |       |              |          |                                                                              |
| 1          | 1383M     | Boulder.....   | 20.02                        | 3.61  | .52          | 10237    | 13477                                                                        |
| 1          | 1523C     | Boulder.....   | 18.68                        | 5.99  | .55          | 10143    | 13570                                                                        |
| FLORIDA    |           |                |                              |       |              |          |                                                                              |
| 1          | 3270C     | Orange.....    | 21.00                        | 5.17  | .45          | 8127     | 11076                                                                        |
| GEORGIA    |           |                |                              |       |              |          |                                                                              |
| 1          | 4156M     | Chattanooga... | 2.85                         | 7.84  | .67          | 14198    | 16039                                                                        |
| 1          | 4320C     | Chattanooga... | 3.80                         | 14.49 | 1.27         | 12791    | 15939                                                                        |
| ILLINOIS   |           |                |                              |       |              |          |                                                                              |
| 24         | 2854M     | Clinton.....   | 13.43                        | 9.18  | 3.35         | 10937    | 14395                                                                        |
| 24         | 2972C     | Clinton.....   | 11.44                        | 10.71 | 4.94         | 10958    | 14422                                                                        |
| 25         | 2856M     | Clinton.....   | 11.64                        | 8.66  | 3.41         | 11290    | 14416                                                                        |
| 35         | 2991C     | Clinton.....   | 11.35                        | 13.40 | 4.76         | 10733    | 14666                                                                        |
| 23         | 4385M     | Clinton.....   | 15.06                        | 9.65  | 1.05         | 10726    | 14435                                                                        |
| 10         | 1648C     | Franklin.....  | 9.50                         | 11.44 | 1.45         | 11506    | 14783                                                                        |
| 13         | 1694M     | Franklin.....  | 9.46                         | 8.12  | 1.63         | 11990    | 14745                                                                        |
| 13         | 1786C     | Franklin.....  | 8.31                         | 10.48 | 1.55         | 11727    | 14651                                                                        |
| 19         | 1871M     | Franklin.....  | 9.90                         | 7.74  | .48          | 12001    | 14699                                                                        |
| 19         | 1926C     | Franklin.....  | 14.91                        | 8.93  | .52          | 10958    | 14545                                                                        |
| 19         | 2020C     | Franklin.....  | 10.72                        | 9.36  | .91          | 11686    | 14800                                                                        |
| 18         | 1741M     | La Salle.....  | 13.87                        | 10.31 | 3.44         | 10985    | 14790                                                                        |
| 18         | 1779C     | La Salle.....  | 12.39                        | 8.92  | 3.92         | 11399    | 14784                                                                        |
| 26         | 3003      | Logan.....     | 15.68                        | 12.09 | 3.51         | 10215    | 14482                                                                        |
| 9          | 1625M     | Macoupin.....  | 13.29                        | 8.90  | 4.12         | 11162    | 14641                                                                        |
| 9          | 1635C     | Macoupin.....  | 13.54                        | 10.74 | 4.03         | 10807    | 14599                                                                        |
| 9          | 1639C     | Macoupin.....  | 13.72                        | 10.32 | 3.96         | 10870    | 14627                                                                        |
| 9          | 4247C     | Macoupin.....  | 15.25                        | 15.35 | 3.81         | 9790     | 14528                                                                        |
| 20         | 2731C     | Macoupin.....  | 14.68                        | 13.68 | 3.88         | 10053    | 14400                                                                        |
| 4          | 1341M     | Madison.....   | 15.09                        | 7.42  | .83          | 11151    | 14533                                                                        |
| 4          | 1417C     | Madison.....   | 12.91                        | 11.64 | 1.32         | 10804    | 14552                                                                        |

TABLE 21  
UNIT COAL VALUES—(Continued)

| State No. | Table No. | COUNTY         | ANALYSES OF COAL AS RECEIVED |       |         |          | "Unit Coal" Basis                                                            |
|-----------|-----------|----------------|------------------------------|-------|---------|----------|------------------------------------------------------------------------------|
|           |           |                | Moisture                     | Ash   | Sulphur | B. t. u. |                                                                              |
|           |           |                |                              |       |         |          | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| 5         | 1556C     | Madison.....   | 17.02                        | 16.79 | 3.29    | 9319     | 14523                                                                        |
| 7         | 1609M     | Madison.....   | 11.87                        | 11.58 | 4.75    | 10768    | 14425                                                                        |
| 7         | 1611C     | Madison.....   | 11.46                        | 17.31 | 4.40    | 10026    | 14542                                                                        |
| 7         | 1780C     | Madison.....   | 10.83                        | 13.18 | 4.53    | 10816    | 14618                                                                        |
| 21        | 2770M     | Madison.....   | 15.23                        | 9.03  | 1.59    | 10901    | 14595                                                                        |
| 21        | 2852C     | Madison.....   | 15.54                        | 10.93 | 1.38    | 10507    | 14517                                                                        |
| 22        | 2772M     | Madison.....   | 13.51                        | 10.15 | 4.01    | 10881    | 14566                                                                        |
| 22        | 2905C     | Madison.....   | 11.91                        | 13.01 | 5.34    | 10615    | 14554                                                                        |
| 22        | 2896C     | Madison.....   | 13.03                        | 14.53 | 4.35    | 10192    | 14480                                                                        |
| 23        | 2774M     | Madison.....   | 13.07                        | 10.06 | 3.59    | 10949    | 14535                                                                        |
| 23        | 2819C     | Madison.....   | 13.47                        | 11.53 | 4.41    | 10510    | 14360                                                                        |
| 23        | 2803C     | Madison.....   | 15.68                        | 15.59 | 3.98    | 9655     | 14483                                                                        |
| 29        | 3911M     | Madison.....   | 14.25                        | 9.44  | 3.72    | 10892    | 14566                                                                        |
| 29        | 3913M     | Madison.....   | 12.69                        | 8.76  | 3.62    | 11236    | 14571                                                                        |
| 29        | 3958C     | Madison.....   | 12.47                        | 12.56 | 4.37    | 10667    | 14602                                                                        |
| 29        | 3963C     | Madison.....   | 13.10                        | 16.00 | 4.17    | 9983     | 14519                                                                        |
| 29        | 3980C     | Madison.....   | 12.25                        | 12.33 | 4.42    | 10719    | 14578                                                                        |
| 15        | 1725M     | Marion.....    | 10.25                        | 12.53 | 3.70    | 11077    | 14683                                                                        |
| 15        | 1761C     | Marion.....    | 9.95                         | 13.23 | 3.87    | 10960    | 14622                                                                        |
| 6         | 1449M     | Montgomery...  | 14.89                        | 7.87  | 3.61    | 11016    | 14518                                                                        |
| 6         | 1661M     | Montgomery...  | 12.90                        | 11.08 | 3.78    | 10856    | 14602                                                                        |
| 6         | 1557C     | Montgomery...  | 14.43                        | 13.28 | 4.01    | 10064    | 14290                                                                        |
| 6         | 1702C     | Montgomery...  | 11.93                        | 14.18 | 4.29    | 10303    | 14332                                                                        |
| 8         | 1627C     | Montgomery...  | 13.20                        | 12.53 | 4.47    | 10514    | 14673                                                                        |
| 1         | 1095M     | St. Clair..... | 11.17                        | 10.32 | 4.22    | 11223    | 14612                                                                        |
| 1         | 1261C     | St. Clair..... | 9.75                         | 13.20 | 4.10    | 11025    | 14675                                                                        |
| 2         | 1152C     | St. Clair..... | 12.03                        | 22.44 | 4.00    | 9149     | 14542                                                                        |
| 30        | 3912M     | St. Clair..... | 9.88                         | 10.81 | 3.83    | 11439    | 14733                                                                        |
| 30        | 4364C     | St. Clair..... | 11.69                        | 13.19 | 4.38    | 10699    | 14625                                                                        |
| 31        | 4251M     | St. Clair..... | 14.38                        | 8.75  | 3.13    | 10858    | 14375                                                                        |
| 31        | 4376C     | St. Clair..... | 13.10                        | 13.25 | 3.66    | 10363    | 14423                                                                        |
| 14        | 1704M     | Sangamon.....  | 13.89                        | 11.26 | 3.83    | 10636    | 14540                                                                        |
| 14        | 1740C     | Sangamon.....  | 12.77                        | 11.78 | 4.16    | 10757    | 14607                                                                        |
| 27        | 2897M     | Sangamon.....  | 14.29                        | 8.18  | 4.41    | 11007    | 14488                                                                        |
| 27        | 3052C     | Sangamon.....  | 16.00                        | 13.77 | 4.05    | 9940     | 14554                                                                        |
| 34        | 4414M     | Saline.....    | 7.51                         | 7.48  | 1.58    | 12686    | 15091                                                                        |
| 34        | 4636C     | Saline.....    | 9.33                         | 11.89 | 2.76    | 11572    | 14984                                                                        |
| 34        | 4622C     | Saline.....    | 7.81                         | 8.38  | 2.36    | 12418    | 15029                                                                        |
| 3         | 1170M     | Williamson.... | 7.50                         | 7.15  | .99     | 12386    | 14646                                                                        |
| 3         | 1318C     | Williamson.... | 8.50                         | 11.28 | 1.72    | 11776    | 14916                                                                        |
| 11        | 1634M     | Williamson.... | 8.30                         | 9.26  | 2.82    | 11999    | 14794                                                                        |
| 11        | 1654C     | Williamson.... | 7.76                         | 10.61 | 1.97    | 11957    | 14835                                                                        |
| 11        | 1660C     | Williamson.... | 8.86                         | 11.66 | 2.46    | 11702    | 14956                                                                        |
| 11        | 1718C     | Williamson.... | 8.61                         | 7.66  | 1.65    | 12236    | 14797                                                                        |
| 12        | 1683M     | Williamson.... | 8.29                         | 10.83 | 2.81    | 11837    | 14867                                                                        |
| 12        | 1762C     | Williamson.... | 8.20                         | 12.95 | 3.48    | 11362    | 14740                                                                        |

TABLE 21  
UNIT COAL VALUES—(Continued)

| State No. | Table No. | COUNTY             | ANALYSES OF COAL AS RECEIVED |       |              |          | "Unit Coal" Basis                                                             |       |
|-----------|-----------|--------------------|------------------------------|-------|--------------|----------|-------------------------------------------------------------------------------|-------|
|           |           |                    | Mois-<br>ture                | Ash   | Sul-<br>phur | B. t. u. | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>100</sub> S.) |       |
| 12        | 4201C     | Williamson . . .   | 15.87                        | 9.52  | 2.34         | 10784    |                                                                               | 14701 |
| 12        | 3907C     | Williamson . . .   | 12.61                        | 10.50 | 2.37         | 11066    |                                                                               | 14647 |
| 12        | 4085C     | Williamson . . .   | 15.31                        | 10.47 | 2.32         | 10820    |                                                                               | 14846 |
| 16        | 1731M     | Williamson . . .   | 9.37                         | 7.37  | 1.25         | 12058    |                                                                               | 14632 |
| 16        | 1820C     | Williamson . . .   | 8.43                         | 9.60  | 1.14         | 11959    |                                                                               | 14772 |
| 28        | 3629M     | Williamson . . .   | 8.72                         | 7.62  | 1.00         | 12200    |                                                                               | 14727 |
| 28        | 3789C     | Williamson . . .   | 7.78                         | 9.98  | 1.32         | 11959    |                                                                               | 14770 |
| INDIANA   |           |                    |                              |       |              |          |                                                                               |       |
| 20        | 3536M     | Clay . . . . .     | 15.38                        | 5.88  | 1.95         | 11680    |                                                                               | 15004 |
| 20        | 3979C     | Clay . . . . .     | 16.91                        | 17.37 | 1.89         | 9524     |                                                                               | 14900 |
| 15        | 3473M     | Greene . . . . .   | 13.53                        | 7.55  | .95          | 11738    |                                                                               | 15028 |
| 15        | 3567C     | Greene . . . . .   | 13.58                        | 8.15  | .91          | 11419    |                                                                               | 14749 |
| 16        | 3564C     | Greene . . . . .   | 10.30                        | 11.75 | 4.23         | 11218    |                                                                               | 14737 |
| 17        | 3516M     | Knox . . . . .     | 10.60                        | 8.30  | 3.69         | 11752    |                                                                               | 14754 |
| 17        | 3981C     | Knox . . . . .     | 12.08                        | 11.02 | 3.65         | 11011    |                                                                               | 14630 |
| 10        | 1853M     | Parke . . . . .    | 11.54                        | 9.62  | 4.41         | 11655    |                                                                               | 15116 |
| 10        | 1979C     | Parke . . . . .    | 10.72                        | 8.57  | 3.83         | 11767    |                                                                               | 14857 |
| 19        | 3534M     | Parke . . . . .    | 13.70                        | 5.91  | 2.66         | 11930    |                                                                               | 15036 |
| 7         | 1824M     | Pike . . . . .     | 10.18                        | 8.12  | 3.96         | 12181    |                                                                               | 15193 |
| 7         | 1881C     | Pike . . . . .     | 8.90                         | 9.21  | 3.74         | 12008    |                                                                               | 14946 |
| 7         | 1882C     | Pike . . . . .     | 11.12                        | 9.35  | 3.78         | 11549    |                                                                               | 14811 |
| 12        | 2701M     | Pike . . . . .     | 11.29                        | 6.87  | 3.09         | 11921    |                                                                               | 14772 |
| 12        | 2759C     | Pike . . . . .     | 10.57                        | 11.65 | 3.87         | 11266    |                                                                               | 14818 |
| 18        | 3525M     | Pike . . . . .     | 12.88                        | 6.14  | 1.70         | 11801    |                                                                               | 14728 |
| 18        | 3801C     | Pike . . . . .     | 11.13                        | 6.98  | 1.64         | 12031    |                                                                               | 14856 |
| 1         | 1410M     | Sullivan . . . . . | 13.25                        | 9.16  | 1.87         | 11360    |                                                                               | 14857 |
| 1         | 1507C     | Sullivan . . . . . | 11.40                        | 13.40 | 2.50         | 11061    |                                                                               | 15032 |
| 4         | 1775M     | Sullivan . . . . . | 14.86                        | 7.35  | 2.26         | 11324    |                                                                               | 14759 |
| 4         | 1844C     | Sullivan . . . . . | 13.99                        | 14.32 | 2.31         | 10318    |                                                                               | 14730 |
| 5         | 1773M     | Sullivan . . . . . | 12.14                        | 8.96  | 3.54         | 11516    |                                                                               | 14875 |
| 5         | 1859C     | Sullivan . . . . . | 12.03                        | 10.88 | 4.27         | 11192    |                                                                               | 14726 |
| 6         | 1772M     | Sullivan . . . . . | 10.45                        | 9.58  | 4.04         | 11745    |                                                                               | 14995 |
| 6         | 1875C     | Sullivan . . . . . | 10.80                        | 12.62 | 4.39         | 11185    |                                                                               | 14990 |
| 11        | 1883M     | Sullivan . . . . . | 14.23                        | 5.72  | .89          | 11722    |                                                                               | 14764 |
| 11        | 2087C     | Sullivan . . . . . | 12.15                        | 8.14  | 1.41         | 11761    |                                                                               | 14934 |
| 8         | 1828M     | Vigo . . . . .     | 10.68                        | 12.24 | 4.38         | 11261    |                                                                               | 14984 |
| 8         | 2037C     | Vigo . . . . .     | 9.55                         | 10.61 | 3.72         | 11759    |                                                                               | 15042 |
| 9         | 1848M     | Vigo . . . . .     | 13.73                        | 8.65  | 3.00         | 11360    |                                                                               | 14891 |
| 9         | 1960C     | Vigo . . . . .     | 13.53                        | 10.76 | 3.15         | 10948    |                                                                               | 14759 |
| 9         | 1973C     | Vigo . . . . .     | 12.82                        | 10.30 | 3.27         | 11119    |                                                                               | 14752 |
| 13        | 3467M     | Vigo . . . . .     | 13.43                        | 7.34  | 2.16         | 11448    |                                                                               | 14642 |
| 13        | 3748C     | Vigo . . . . .     | 12.97                        | 12.09 | 3.18         | 10899    |                                                                               | 14871 |
| 14        | 3491M     | Vigo . . . . .     | 13.62                        | 7.11  | 3.28         | 11543    |                                                                               | 14797 |
| 14        | 3775C     | Vigo . . . . .     | 7.88                         | 14.20 | 5.14         | 11146    |                                                                               | 14725 |

TABLE 21  
UNIT COAL VALUES—(Continued)

| State No.        | Table No. | COUNTY          | ANALYSES OF COAL AS RECEIVED |       |              |          | "Unit Coal" Basis<br>B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
|------------------|-----------|-----------------|------------------------------|-------|--------------|----------|---------------------------------------------------------------------------------------------------|
|                  |           |                 | Mois-<br>ture                | Ash   | Sul-<br>phur | B. t. u. |                                                                                                   |
| 2                | 1425M     | Warrick.....    | 9.28                         | 9.34  | 4.44         | 11799    | 14806                                                                                             |
| 2                | 1495C     | Warrick.....    | 9.62                         | 13.02 | 4.43         | 11122    | 14754                                                                                             |
| 3                | 1759M     | Warrick.....    | 11.28                        | 7.63  | 3.58         | 11792    | 14792                                                                                             |
| 3                | 1941C     | Warrick.....    | 13.18                        | 15.63 | 4.79         | 10030    | 14547                                                                                             |
| IOWA             |           |                 |                              |       |              |          |                                                                                                   |
| 1                | 1270M     | Davis.....      | 11.35                        | 10.51 | 4.72         | 11345    | 14871                                                                                             |
| 1                | 1347C     | Davis.....      | 8.24                         | 16.00 | 5.03         | 11027    | 15026                                                                                             |
| 2                | 1289M     | Marion.....     | 15.65                        | 11.64 | 5.10         | 10289    | 14548                                                                                             |
| 2                | 1570C     | Marion.....     | 14.21                        | 15.22 | 4.66         | 10019    | 14652                                                                                             |
| 3                | 1312M     | Polk.....       | 14.42                        | 10.99 | 5.89         | 10640    | 14680                                                                                             |
| 3                | 1434C     | Polk.....       | 13.88                        | 14.01 | 6.15         | 10244    | 14698                                                                                             |
| 4                | 1323M     | Appanoose.....  | 17.13                        | 7.07  | 4.00         | 10931    | 14694                                                                                             |
| 4                | 1437C     | Appanoose.....  | 14.08                        | 10.96 | 4.26         | 10723    | 14650                                                                                             |
| 5                | 1332M     | Lucas.....      | 18.69                        | 7.73  | 2.39         | 10505    | 14496                                                                                             |
| 5                | 1433C     | Lucas.....      | 15.39                        | 12.63 | 3.19         | 10242    | 14567                                                                                             |
| INDIAN TERRITORY |           |                 |                              |       |              |          |                                                                                                   |
|                  |           | (Town)          |                              |       |              |          |                                                                                                   |
| 1                | 1059M     | Henryetta.....  | 8.87                         | 8.63  | 1.62         | 12096    | 14848                                                                                             |
| 1                | 1138C     | Henryetta.....  | 7.04                         | 10.01 | 1.92         | 12202    | 14929                                                                                             |
| 2                | 1071M     | Hartshorne..... | 1.46                         | 6.40  | 1.38         | 14040    | 15375                                                                                             |
| 2                | 1184C     | Hartshorne..... | 4.45                         | 11.00 | 1.52         | 12607    | 15129                                                                                             |
| 3                | 1080M     | Edwards.....    | 2.93                         | 10.30 | 3.73         | 12591    | 14786                                                                                             |
| 3                | 1274C     | Edwards.....    | 4.61                         | 11.14 | 3.63         | 12319    | 14918                                                                                             |
| 4                | 1151M     | Lehigh.....     | 6.50                         | 9.31  | 3.67         | 11842    | 14318                                                                                             |
| 4                | 1470C     | Lehigh.....     | 6.24                         | 13.21 | 3.96         | 11228    | 14267                                                                                             |
| 5                | 1481C     | Lehigh.....     | 8.29                         | 25.05 | 3.95         | 9110     | 14264                                                                                             |
| 9                | 4020C     | Panama.....     | 5.11                         | 8.03  | 1.18         | 13662    | 15897                                                                                             |
| KANSAS           |           |                 |                              |       |              |          |                                                                                                   |
|                  |           | (County)        |                              |       |              |          |                                                                                                   |
| 1                | 1018M     | Crawford.....   | 2.91                         | 9.55  | 3.79         | 12947    | 15063                                                                                             |
| 1                | 1097C     | Crawford.....   | 4.99                         | 12.97 | 4.28         | 12242    | 15293                                                                                             |
| 2                | 1015M     | Crawford.....   | 2.44                         | 10.60 | 5.63         | 13043    | 15373                                                                                             |
| 2                | 1122C     | Crawford.....   | 4.18                         | 17.91 | 6.27         | 11642    | 15511                                                                                             |
| 3                | 1037M     | Cherokee.....   | 2.54                         | 9.87  | 4.47         | 13340    | 15535                                                                                             |
| 3                | 1086C     | Cherokee.....   | 2.50                         | 12.45 | 5.68         | 12900    | 15589                                                                                             |
| 4                | 1473C     | Atchison.....   | 6.95                         | 12.19 | 8.04         | 11905    | 15244                                                                                             |
| 5                | 1411M     | Cherokee.....   | 5.11                         | 8.90  | 4.34         | 12926    | 15332                                                                                             |
| 5                | 1567C     | Cherokee.....   | 4.10                         | 10.54 | 3.77         | 12895    | 15412                                                                                             |
| 6                | 2790M     | Linn.....       | 11.13                        | 12.60 | 2.41         | 11219    | 15011                                                                                             |
| 6                | 2843C     | Linn.....       | 9.04                         | 15.72 | 3.72         | 11142    | 15231                                                                                             |



TABLE 21

UNIT COAL VALUES—(Continued)

| State No. | Table No. | COUNTY          | ANALYSES OF COAL AS RECEIVED |       |              |          | "Unit Coal" Basis                                                            |
|-----------|-----------|-----------------|------------------------------|-------|--------------|----------|------------------------------------------------------------------------------|
|           |           |                 | Mois-<br>ture                | Ash   | Sul-<br>phur | B. t. u. |                                                                              |
|           |           |                 |                              |       |              |          | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| KENTUCKY  |           |                 |                              |       |              |          |                                                                              |
| 1         | 1321M     | Bell.....       | 2.91                         | 3.53  | .89          | 14322    | 15280                                                                        |
| 1         | 2350M     | Bell.....       | 3.42                         | 3.18  | 1.53         | 14375    | 15491                                                                        |
| 1         | 1474C     | Bell.....       | 3.10                         | 4.39  | 1.22         | 14148    | 15397                                                                        |
| 1         | 2445C     | Bell.....       | 5.21                         | 8.22  | 1.12         | 13214    | 15427                                                                        |
| 2         | 1365M     | Hopkins.....    | 8.49                         | 7.10  | 3.53         | 12344    | 14858                                                                        |
| 2         | 1461C     | Hopkins.....    | 7.91                         | 9.13  | 3.62         | 12200    | 14979                                                                        |
| 3         | 1367M     | Hopkins.....    | 7.98                         | 9.30  | 4.03         | 11965    | 14748                                                                        |
| 3         | 1506C     | Hopkins.....    | 7.92                         | 10.06 | 3.52         | 12022    | 14944                                                                        |
| 4         | 1382M     | Webster.....    | 4.61                         | 7.40  | 3.33         | 12861    | 14836                                                                        |
| 4         | 1539C     | Webster.....    | 5.27                         | 14.18 | 4.54         | 11950    | 15240                                                                        |
| 5         | 2270M     | Harlan.....     | 4.32                         | 2.28  | .48          | 14121    | 15165                                                                        |
| 5         | 2528C     | Harlan.....     | 4.36                         | 3.70  | .67          | 13923    | 15217                                                                        |
| 6         | 2405M     | Johnson.....    | 6.95                         | 2.03  | .48          | 13687    | 15054                                                                        |
| 6         | 2592C     | Johnson.....    | 5.12                         | 2.76  | .57          | 13743    | 14975                                                                        |
| 7         | 2453M     | Muhlenberg..... | 8.76                         | 9.42  | 4.07         | 11965    | 14919                                                                        |
| 7         | 2595C     | Muhlenberg..... | 8.47                         | 9.48  | 3.60         | 11986    | 14886                                                                        |
| 8         | 3678M     | Union.....      | 7.46                         | 4.60  | .97          | 13489    | 15443                                                                        |
| 8         | 3860C     | Union.....      | 5.46                         | 7.92  | 1.18         | 13239    | 15444                                                                        |
| 9         | 3722M     | Ohio.....       | 10.03                        | 7.67  | 2.56         | 12076    | 14758                                                                        |
| 9         | 3723M     | Ohio.....       | 9.89                         | 8.69  | 2.45         | 11927    | 14872                                                                        |
| 9         | 3865C     | Ohio.....       | 8.70                         | 8.96  | 3.14         | 12078    | 14922                                                                        |
| MARYLAND  |           |                 |                              |       |              |          |                                                                              |
| 1         | 2018M     | Garrett.....    | 2.47                         | 9.55  | 1.23         | 13853    | 15936                                                                        |
| 1         | 2274C     | Garrett.....    | 2.33                         | 13.13 | 1.49         | 13255    | 15942                                                                        |
| MISSOURI  |           |                 |                              |       |              |          |                                                                              |
| 1         | 1043M     | Bates.....      | 4.92                         | 14.52 | 5.34         | 11992    | 15334                                                                        |
| 1         | 1126C     | Bates.....      | 8.33                         | 19.36 | 5.25         | 10586    | 15209                                                                        |
| 2         | 1226M     | Macon.....      | 14.74                        | 7.78  | 3.79         | 11185    | 14705                                                                        |
| 2         | 1348C     | Macon.....      | 11.50                        | 16.86 | 5.16         | 10179    | 14709                                                                        |
| 3         | 1549C     | Putnam.....     | 15.71                        | 20.78 | 3.69         | 8840     | 14471                                                                        |
| 4         | 1446M     | Morgan.....     | 13.34                        | 6.91  | 5.06         | 11605    | 14855                                                                        |
| 4         | 1516C     | Morgan.....     | 12.67                        | 4.83  | 5.12         | 12487    | 15426                                                                        |
| 5         | 2795M     | Randolph.....   | 13.38                        | 10.02 | 4.48         | 11084    | 14808                                                                        |
| 5         | 2865C     | Randolph.....   | 12.92                        | 13.62 | 5.03         | 10548    | 14793                                                                        |
| 6         | 2817M     | Randolph.....   | 14.01                        | 10.29 | 5.23         | 11030    | 14955                                                                        |
| 6         | 2904C     | Randolph.....   | 13.80                        | 11.74 | 5.60         | 10796    | 14929                                                                        |
| 7         | 2823M     | Adair.....      | 17.19                        | 9.28  | 2.76         | 10598    | 14677                                                                        |
| 7         | 2936C     | Adair.....      | 16.36                        | 19.51 | 3.53         | 9007     | 14566                                                                        |
| 7         | 2942C     | Adair.....      | 17.30                        | 23.38 | 2.94         | 8240     | 14496                                                                        |
| 7         | 2937C     | Adair.....      | 16.39                        | 20.18 | 3.12         | 8946     | 14626                                                                        |
| 10        | 4197M     | Macon.....      | 15.41                        | 11.61 | 3.78         | 10582    | 14853                                                                        |
| 10        | 4257C     | Macon.....      | 15.23                        | 20.50 | 3.69         | 9099     | 14712                                                                        |

TABLE 21  
UNIT COAL VALUES—(Continued)

| State No.    | Table No. | COUNTY        | ANALYSES OF COAL AS RECEIVED |       |              |                                 | "Unit Coal" Basis |
|--------------|-----------|---------------|------------------------------|-------|--------------|---------------------------------|-------------------|
|              |           |               | Mois-<br>ture                | Ash   | Sul-<br>phur | B. t. u.                        |                   |
|              |           |               |                              |       |              | B. t. u. — 5000 S               |                   |
|              |           |               |                              |       |              | 1.00 —                          |                   |
|              |           |               |                              |       |              | (1.08 Ash + $\frac{22}{40}$ S.) |                   |
| MONTANA      |           |               |                              |       |              |                                 |                   |
| 1            | 1298C     | Carbon.....   | 11.05                        | 10.97 | 1.73         | 10539                           | 13727             |
| 2            | 4234C     | Carbon.....   | 8.51                         | 15.39 | .60          | 10478                           | 14017             |
| 3            | 4271C     | Carbon.....   | 8.56                         | 13.39 | .54          | 10685                           | 13899             |
| NEW MEXICO   |           |               |                              |       |              |                                 |                   |
| 1            | (1025)M   |               |                              |       |              |                                 |                   |
|              | (1026)M   | McKinley..... | 10.96                        | 4.01  | .52          | 11885                           | 14048             |
| 1            | 1278C     | McKinley..... | 12.29                        | 6.99  | .63          | 11252                           | 14058             |
| 2            | 1028M     | McKinley..... | 9.68                         | 8.08  | 1.55         | 11623                           | 14301             |
| 2            | 1307C     | McKinley..... | 10.79                        | 18.66 | 1.26         | 9907                            | 14398             |
| 3            | 3221M     | Colfax.....   | 2.50                         | 9.13  | .72          | 13127                           | 15006             |
| 3            | 3295C     | Colfax.....   | 3.45                         | 16.67 | .73          | 11893                           | 15173             |
| 3            | 3307C     | Colfax.....   | 4.36                         | 15.92 | .83          | 11912                           | 15220             |
| 3            | 3308C     | Colfax.....   | 2.75                         | 15.52 | .64          | 12166                           | 15141             |
| 4            | 3228M     | Colfax.....   | 2.19                         | 11.11 | .57          | 13063                           | 15246             |
| 4            | 3331C     | Colfax.....   | 2.78                         | 14.57 | .61          | 12294                           | 15113             |
| 4            | 3315C     | Colfax.....   | 3.38                         | 13.54 | .61          | 12445                           | 15202             |
| 5            | 3226M     | Colfax.....   | 2.25                         | 12.37 | .75          | 13030                           | 15472             |
| 5            | 3294C     | Colfax.....   | 2.72                         | 14.57 | .69          | 12539                           | 15408             |
| NORTH DAKOTA |           |               |                              |       |              |                                 |                   |
| 1            | 1971M     | Stark.....    | 42.06                        | 7.66  | 1.13         | 6158                            | 12441             |
| 1            | 1279C     | Stark.....    | 35.38                        | 9.35  | 1.55         | 6923                            | 12756             |
| 1            | 2289C     | Stark.....    | 32.64                        | 11.42 | 3.54         | 6970                            | 12798             |
| 2            | 1730M     | Williams..... | 41.13                        | 5.36  | .72          | 6485                            | 12242             |
| 2            | 1416C     | Williams..... | 36.78                        | 5.09  | .48          | 7204                            | 12496             |
| 2            | 2365C     | Williams..... | 36.13                        | 5.04  | .59          | 7326                            | 12558             |
| 3            | 1935M     | McLean.....   | 40.53                        | 5.05  | .76          | 6644                            | 12325             |
| 3            | 2243C     | McLean.....   | 35.96                        | 7.75  | 1.15         | 7069                            | 12740             |
| OHIO         |           |               |                              |       |              |                                 |                   |
| 6            | 2095M     | Belmont.....  | 3.99                         | 8.07  | 3.49         | 13102                           | 15144             |
| 6            | 2392C     | Belmont.....  | 5.31                         | 8.52  | 3.33         | 12843                           | 15153             |
| 11           | 3986M     | Belmont.....  | 4.13                         | 7.96  | 4.12         | 13088                           | 15155             |
| 11           | 4157C     | Belmont.....  | 3.44                         | 12.94 | 4.32         | 12287                           | 15049             |
| 12           | 4151C     | Belmont.....  | 4.14                         | 9.38  | 3.96         | 12874                           | 15172             |
| 12           | 4178C     | Belmont.....  | 2.97                         | 9.97  | 3.65         | 12933                           | 15133             |
| 7            | 2090M     | Guernsey..... | 6.28                         | 7.30  | 3.55         | 12701                           | 14930             |
| 7            | 2656C     | Guernsey..... | 6.65                         | 10.55 | 3.13         | 12179                           | 14984             |

TABLE 21  
UNIT COAL VALUES—(Continued)

| State No. | Table No. | COUNTY         | ANALYSES OF COAL AS RECEIVED |       |              |          | "Unit Coal" Basis                                                            |
|-----------|-----------|----------------|------------------------------|-------|--------------|----------|------------------------------------------------------------------------------|
|           |           |                | Mois-<br>ture                | Ash   | Sul-<br>phur | B. t. u. | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| 1         | 1896M     | Jackson.....   | 8.45                         | 6.73  | 3.10         | 12249    | 14647                                                                        |
| 1         | 2071C     | Jackson.....   | 7.71                         | 11.95 | 4.61         | 11515    | 14685                                                                        |
| 2         | 1898M     | Jackson.....   | 9.38                         | 7.62  | 4.08         | 11898    | 14590                                                                        |
| 2         | 2109C     | Jackson.....   | 9.01                         | 11.34 | 4.02         | 11495    | 14758                                                                        |
| 4         | 1910M     | Jefferson..... | 4.06                         | 7.75  | 3.67         | 13147    | 15152                                                                        |
| 4         | 2083C     | Jefferson..... | 3.53                         | 9.12  | 3.47         | 13072    | 15226                                                                        |
| 5         | 1944M     | Jefferson..... | 4.69                         | 6.01  | 1.54         | 13325    | 15060                                                                        |
| 5         | 2062C     | Jefferson..... | 4.34                         | 7.30  | 1.72         | 13178    | 15078                                                                        |
| 3         | 1900M     | Perry.....     | 10.78                        | 6.13  | 1.11         | 11993    | 14563                                                                        |
| 3         | 2144C     | Perry.....     | 9.90                         | 11.58 | 1.81         | 11277    | 14605                                                                        |
| 8         | 2119M     | Perry.....     | 8.92                         | 5.85  | 3.00         | 12328    | 14653                                                                        |
| 8         | 2559C     | Perry.....     | 7.55                         | 8.37  | 2.84         | 12128    | 14644                                                                        |
| 10        | 3969M     | Tuscarawas.... | 4.46                         | 8.54  | 3.73         | 12845    | 15022                                                                        |
| 10        | 4059C     | Tuscarawas.... | 4.49                         | 7.53  | 2.93         | 12958    | 14938                                                                        |
| 9         | 2208M     | Vinton.....    | 6.79                         | 7.66  | 3.34         | 12514    | 14858                                                                        |
| 9         | 2310C     | Vinton.....    | 5.59                         | 8.29  | 3.15         | 12773    | 15068                                                                        |
| 9         | 2311C     | Vinton.....    | 8.10                         | 11.93 | 3.35         | 11563    | 14766                                                                        |

## PENNSYLVANIA

|    |       |                |      |       |      |       |       |
|----|-------|----------------|------|-------|------|-------|-------|
| 10 | 2080M | Allegheny..... | 3.67 | 5.46  | 1.37 | 13874 | 15395 |
| 10 | 2229C | Allegheny..... | 2.61 | 6.17  | 1.26 | 13997 | 15475 |
| 13 | 3437M | Allegheny..... | 2.53 | 8.98  | 2.21 | 13356 | 15303 |
| 13 | 3879C | Allegheny..... | 2.65 | 13.16 | 2.16 | 12816 | 15507 |
| 8  | 2014M | Cambria.....   | 3.49 | 5.71  | .95  | 14515 | 16108 |
| 8  | 2152C | Cambria.....   | 3.51 | 6.63  | .94  | 14279 | 16025 |
| 16 | 4029M | Cambria.....   | 2.74 | 7.23  | 1.51 | 14144 | 15876 |
| 16 | 4169C | Cambria.....   | 4.25 | 7.87  | 1.59 | 13513 | 15553 |
| 18 | 4348M | Cambria.....   | 2.66 | 8.56  | 2.97 | 13995 | 16014 |
| 18 | 4509C | Cambria.....   | 4.46 | 8.47  | 1.49 | 13682 | 15903 |
| 21 | 4412M | Fayette.....   | 2.82 | 7.37  | 1.22 | 13991 | 15731 |
| 21 | 4609C | Fayette.....   | 5.13 | 8.71  | .86  | 13365 | 15675 |
| 15 | 4027M | Indiana.....   | 2.84 | 8.27  | 3.11 | 14079 | 16094 |
| 15 | 4082C | Indiana.....   | 3.13 | 9.81  | 3.77 | 13795 | 16159 |
| 15 | 4104C | Indiana.....   | 2.57 | 10.33 | 3.97 | 13712 | 16072 |
| 17 | 4337  | Indiana.....   | 2.22 | 8.42  | 1.54 | 13801 | 15624 |
| 17 | 4421  | Indiana.....   | 4.35 | 11.90 | 1.51 | 12964 | 15725 |
| 9  | 2016M | Somerset.....  | 2.63 | 10.21 | 2.05 | 13705 | 15963 |
| 9  | 2199C | Somerset.....  | 3.09 | 11.33 | 2.04 | 13424 | 15945 |
| 5  | 1966M | Washington.... | 3.01 | 4.83  | .73  | 14197 | 15499 |
| 5  | 2068C | Washington.... | 2.46 | 6.05  | .88  | 14013 | 15430 |
| 11 | 3421M | Washington.... | 2.50 | 5.34  | 1.14 | 14146 | 15465 |
| 11 | 3532C | Washington.... | 1.95 | 7.29  | 1.18 | 13775 | 15320 |
| 12 | 3441M | Washington.... | 2.60 | 5.63  | 1.19 | 14184 | 15689 |
| 12 | 4098C | Washington.... | 1.96 | 9.25  | 2.19 | 13622 | 15560 |

TABLE 21  
UNIT COAL VALUES—(Continued)

| State No. | Table No. | COUNTY         | ANALYSES OF COAL AS RECEIVED |       |              |          | "Unit Coal" Basis                                                            |
|-----------|-----------|----------------|------------------------------|-------|--------------|----------|------------------------------------------------------------------------------|
|           |           |                | Mois-<br>ture                | Ash   | Sul-<br>phur | B. t. u. | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| 4         | 1942M     | Westmoreland.. | 2.73                         | 9.13  | 1.33         | 13613    | 15629                                                                        |
| 4         | 2187C     | Westmoreland.. | 3.15                         | 10.41 | 1.26         | 13406    | 15714                                                                        |
| 6         | 1968M     | Westmoreland.. | 4.08                         | 9.50  | 1.64         | 13268    | 15557                                                                        |
| 6         | 2161C     | Westmoreland.. | 3.24                         | 12.52 | 1.94         | 12879    | 15555                                                                        |
| 7         | 1994M     | Westmoreland.. | 3.30                         | 11.18 | 1.79         | 13378    | 15887                                                                        |
| 7         | 2154C     | Westmoreland.. | 4.09                         | 12.47 | 2.08         | 13153    | 16050                                                                        |
| 19        | 4352M     | Westmoreland.. | 2.01                         | 6.32  | 1.39         | 14152    | 15579                                                                        |
| 19        | 4489C     | Westmoreland.. | 3.39                         | 8.36  | 1.05         | 13699    | 15685                                                                        |
| 20        | 4350M     | Westmoreland.. | 2.48                         | 9.24  | 3.03         | 13822    | 15936                                                                        |
| 20        | 4517C     | Westmoreland.. | 4.00                         | 10.54 | 2.85         | 13347    | 15899                                                                        |
| 22        | 4498C     | Westmoreland.. | 3.98                         | 10.16 | 1.00         | 13311    | 15693                                                                        |

## TENNESSEE

|    |       |                  |      |       |      |       |       |
|----|-------|------------------|------|-------|------|-------|-------|
| 1  | 2907M | Claiborne. ....  | 3.71 | 4.74  | 1.28 | 13804 | 15195 |
| 1  | 3016C | Claiborne. ....  | 4.81 | 11.15 | 1.58 | 12569 | 15180 |
| 2  | 2931M | Campbell. ....   | 3.61 | 3.41  | .83  | 14130 | 15271 |
| 2  | 3129C | Campbell. ....   | 5.09 | 6.81  | .98  | 13295 | 15222 |
| 3  | 2929M | Campbell. ....   | 4.25 | 4.13  | .93  | 13666 | 15004 |
| 3  | 3040C | Campbell. ....   | 5.38 | 7.05  | .99  | 13048 | 15033 |
| 4  | 2956M | Roane. ....      | 3.25 | 6.61  | .85  | 13514 | 15112 |
| 4  | 3058C | Roane. ....      | 6.39 | 9.53  | .98  | 12578 | 15135 |
| 5  | 2958M | Morgan. ....     | 2.25 | 6.91  | 2.96 | 13851 | 15456 |
| 5  | 3050C | Morgan. ....     | 5.59 | 9.76  | 3.23 | 12841 | 15445 |
| 6  | 2977M | Cumberland. .... | 3.80 | 4.50  | .78  | 14182 | 15557 |
| 6  | 3102C | Cumberland. .... | 3.89 | 14.43 | .78  | 12514 | 15574 |
| 7  | 2979M | Fentress. ....   | 3.46 | 9.08  | 2.42 | 12983 | 15073 |
| 7  | 3133C | Fentress. ....   | 3.03 | 12.85 | 3.26 | 12602 | 15300 |
| 8  | 3005M | White. ....      | 3.01 | 10.76 | 3.42 | 13104 | 15490 |
| 8  | 3127C | White. ....      | 2.63 | 13.42 | 4.38 | 12715 | 15529 |
| 8  | 3128C | White. ....      | 3.12 | 14.12 | 4.74 | 12517 | 15540 |
| 9  | 2995M | Grundy. ....     | 3.44 | 9.21  | .73  | 13219 | 15292 |
| 9  | 3113C | Grundy. ....     | 3.92 | 14.09 | .94  | 12508 | 15510 |
| 9  | 3114C | Grundy. ....     | 5.68 | 18.55 | .74  | 11480 | 15489 |
| 9  | 3115C | Grundy. ....     | 4.68 | 9.26  | .65  | 13163 | 15454 |
| 10 | 3009M | Marion. ....     | 3.31 | 13.11 | 1.30 | 12193 | 15825 |
| 11 | 3471C | Cumberland. .... | 3.53 | 27.87 | .90  | 10264 | 15514 |

## TEXAS

|   |       |               |       |       |     |      |       |
|---|-------|---------------|-------|-------|-----|------|-------|
| 1 | 1196M | Houston. .... | 33.50 | 10.75 | .56 | 7142 | 13034 |
| 1 | 1456C | Houston. .... | 34.70 | 11.20 | .79 | 7056 | 13298 |
| 2 | 1241M | Wood. ....    | 28.86 | 7.92  | .50 | 7996 | 12794 |
| 2 | 1597C | Wood. ....    | 33.71 | 7.28  | .53 | 7348 | 12594 |



TABLE 21  
UNIT COAL VALUES—(Continued)

| State No. | Table No. | COUNTY     | ANALYSES OF COAL AS RECEIVED |      |              |          | "Unit Coal" Basis<br>B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + $\frac{22}{40}$ S.) |
|-----------|-----------|------------|------------------------------|------|--------------|----------|-------------------------------------------------------------------------------------|
|           |           |            | Mois-<br>ture                | Ash  | Sul-<br>phur | B. t. u. |                                                                                     |
| 3         | 2652M     | Milan..... | 36.01                        | 7.38 | .77          | 7132     | 12759                                                                               |
| 3         | 2734C     | Milan..... | 31.06                        | 7.88 | .99          | 7870     | 13059                                                                               |
| 4         | 2635M     | Wood.....  | 36.80                        | 6.25 | .53          | 7101     | 12598                                                                               |
| 4         | 2717C     | Wood.....  | 33.85                        | 7.30 | .51          | 7497     | 12885                                                                               |

## UTAH

|   |       |              |       |      |      |       |       |
|---|-------|--------------|-------|------|------|-------|-------|
| 1 | 3199C | Carbon.....  | 6.05  | 4.87 | .55  | 13151 | 14848 |
| 2 | 3200M | Summitt..... | 14.07 | 6.26 | 1.28 | 10471 | 13262 |

## VIRGINIA

|   |       |               |      |       |      |       |       |
|---|-------|---------------|------|-------|------|-------|-------|
| 1 | 2268M | Lee.....      | 5.69 | 8.11  | 2.31 | 13117 | 15428 |
| 1 | 2420C | Lee.....      | 4.06 | 4.73  | 1.20 | 13826 | 15267 |
| 2 | 2476C | Lee.....      | 3.35 | 5.58  | .92  | 13932 | 15410 |
| 3 | 2382C | Wise.....     | 3.05 | 4.48  | .67  | 14470 | 15736 |
| 4 | 2323M | Lee.....      | 3.89 | 3.06  | .34  | 14144 | 15253 |
| 4 | 2358C | Lee.....      | 4.35 | 4.33  | .79  | 13939 | 15353 |
| 5 | 4093M | Montgomery..  | 2.98 | 21.94 | .68  | 11669 | 15949 |
| 5 | 4287C | Montgomery..  | 4.80 | 18.03 | .63  | 11961 | 15825 |
| 5 | 4294C | Montgomery..  | 7.52 | 16.23 | .65  | 11893 | 15900 |
| 6 | 4305M | Tazewell..... | 2.60 | 4.48  | 1.35 | 14636 | 15867 |
| 6 | 4573C | Tazewell..... | 5.62 | 9.79  | 1.21 | 13264 | 15880 |

## WASHINGTON

|   |       |               |       |       |     |       |       |
|---|-------|---------------|-------|-------|-----|-------|-------|
| 1 | 2456M | King.....     | 17.97 | 7.78  | .43 | 10006 | 13604 |
| 1 | 2687C | King.....     | 16.04 | 11.53 | .61 | 9938  | 13920 |
| 1 | 2686C | King.....     | 14.30 | 11.37 | .72 | 10208 | 13930 |
| 2 | 2458M | Kittitas..... | 3.39  | 10.39 | .33 | 12847 | 15059 |
| 2 | 3098C | Kittitas..... | 3.16  | 12.26 | .38 | 12586 | 15070 |

## WEST VIRGINIA

|   |       |              |      |      |      |       |       |
|---|-------|--------------|------|------|------|-------|-------|
| 6 | 1176M | Fayette..... | 2.10 | 3.55 | .75  | 14900 | 15870 |
| 6 | 1390C | Fayette..... | 1.53 | 5.05 | .65  | 14807 | 15944 |
| 7 | 1198M | Fayette..... | 2.12 | 3.55 | .90  | 14915 | 15895 |
| 7 | 1595C | Fayette..... | 3.94 | 4.93 | 1.16 | 14382 | 15898 |
| 8 | 1257M | Fayette..... | 1.90 | 4.87 | .64  | 14452 | 15591 |
| 8 | 1515C | Fayette..... | 4.16 | 7.17 | .90  | 13786 | 15686 |
| 9 | 1208M | Fayette..... | 1.98 | 3.76 | .85  | 14738 | 15825 |
| 9 | 1561C | Fayette..... | 4.08 | 6.58 | .77  | 13925 | 15712 |

TABLE 21

UNIT COAL VALUES—(Continued)

| State No. | Table No. | COUNTY         | ANALYSES OF COAL AS RECEIVED |       |              |          | "Unit Coal" Basis                                                            |
|-----------|-----------|----------------|------------------------------|-------|--------------|----------|------------------------------------------------------------------------------|
|           |           |                | Mois-<br>ture                | Ash   | Sul-<br>phur | B. t. u. | B. t. u. — 5000 S<br>1.00 —<br>(1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| 13        | 1867M     | Fayette.....   | 5.48                         | 2.29  | .79          | 14454    | 15734                                                                        |
| 13        | 2028C     | Fayette.....   | 3.74                         | 3.91  | .89          | 14436    | 15721                                                                        |
| 14        | 1870M     | Fayette.....   | 2.96                         | 7.44  | 1.04         | 13972    | 15741                                                                        |
| 14        | 2004C     | Fayette.....   | 5.09                         | 3.27  | 1.03         | 14110    | 15480                                                                        |
| 19        | 2359M     | Fayette.....   | 3.26                         | 2.46  | .78          | 14773    | 15733                                                                        |
| 19        | 2549C     | Fayette.....   | 2.96                         | 5.01  | .89          | 14425    | 15780                                                                        |
| 2         | 1103M     | Harrison.....  | 1.98                         | 9.08  | 4.20         | 13466    | 15432                                                                        |
| 2         | 1308C     | Harrison.....  | 1.95                         | 7.86  | 3.48         | 13790    | 15536                                                                        |
| 15        | 2039M     | Harrison.....  | 2.80                         | 5.55  | 2.40         | 14105    | 15558                                                                        |
| 15        | 2195C     | Harrison.....  | 2.01                         | 8.55  | 2.54         | 13811    | 15664                                                                        |
| 20        | 2375M     | Kanawha.....   | 2.66                         | 4.44  | 1.14         | 14368    | 15571                                                                        |
| 20        | 2556C     | Kanawha.....   | 2.82                         | 8.03  | 1.38         | 13766    | 15609                                                                        |
| 21        | 2377M     | Kanawha.....   | 3.57                         | 3.62  | 1.14         | 14173    | 15362                                                                        |
| 21        | 2572C     | Kanawha.....   | 3.57                         | 4.85  | 1.32         | 13948    | 15346                                                                        |
| 22        | 3456M     | Kanawha.....   | 2.75                         | 5.49  | .63          | 13813    | 15149                                                                        |
| 22        | 3457M     | Kanawha.....   | 3.49                         | 6.44  | .63          | 13813    | 15449                                                                        |
| 22        | 3905C     | Kanawha.....   | 3.42                         | 7.82  | .83          | 13486    | 15335                                                                        |
| 23        | 3458M     | Kanawha.....   | 3.13                         | 3.54  | .59          | 13963    | 15027                                                                        |
| 23        | 3965C     | Kanawha.....   | 2.05                         | 8.10  | 1.35         | 13707    | 15420                                                                        |
| 23        | 3625C     | Kanawha.....   | 3.25                         | 7.58  | 1.22         | 13523    | 15317                                                                        |
| 25        | 4291M     | Kanawha.....   | 3.91                         | 7.68  | .64          | 13471    | 15199                                                                        |
| 25        | 4360C     | Kanawha.....   | 4.21                         | 7.22  | .64          | 13379    | 15229                                                                        |
| 11        | 1234M     | McDowell.....  | 2.21                         | 5.25  | .44          | 14792    | 16075                                                                        |
| 11        | 1472C     | McDowell.....  | 4.07                         | 11.12 | .51          | 13509    | 16122                                                                        |
| 12        | 1238M     | McDowell.....  | 1.92                         | 4.39  | .52          | 14926    | 16013                                                                        |
| 12        | 1242M     | McDowell.....  | 3.48                         | 3.90  | .73          | 14731    | 15989                                                                        |
| 12        | 1364C     | McDowell.....  | 1.72                         | 6.87  | .68          | 14571    | 16065                                                                        |
| 1         | 1088M     | Marion.....    | 1.40                         | 6.67  | 1.59         | 14063    | 15447                                                                        |
| 1         | 1213C     | Marion.....    | 1.75                         | 6.34  | .90          | 14107    | 15450                                                                        |
| 16        | 2041M     | Marion.....    | 2.89                         | 5.71  | .69          | 14540    | 16020                                                                        |
| 16        | 2264C     | Marion.....    | 5.57                         | 8.37  | 1.20         | 13093    | 15701                                                                        |
| 10        | 1240M     | Mercer.....    | 2.93                         | 3.62  | .48          | 14924    | 16039                                                                        |
| 10        | 1471C     | Mercer.....    | 1.75                         | 4.58  | .56          | 15023    | 16125                                                                        |
| 18        | 2348M     | Mingo.....     | 2.81                         | 6.50  | .66          | 13957    | 15504                                                                        |
| 18        | 2527C     | Mingo.....     | 2.86                         | 5.83  | .67          | 14106    | 15554                                                                        |
| 3         | 1108M     | Monongalia.... | 2.90                         | 8.19  | .75          | 13941    | 15829                                                                        |
| 3         | 1252C     | Monongalia.... | 2.29                         | 10.23 | 1.06         | 13558    | 15689                                                                        |
| 4         | 1116M     | Preston.....   | 2.26                         | 7.74  | .85          | 13999    | 15697                                                                        |
| 4         | 2054M     | Preston.....   | 3.57                         | 6.21  | .85          | 14218    | 15882                                                                        |
| 4         | 1262C     | Preston.....   | 1.48                         | 8.39  | .90          | 14069    | 15764                                                                        |
| 4         | 2250C     | Preston.....   | 3.91                         | 10.11 | 1.07         | 13370    | 15744                                                                        |
| 17        | 2056M     | Preston.....   | 3.22                         | 7.33  | 1.73         | 13995    | 15822                                                                        |
| 17        | 2332C     | Preston.....   | 3.46                         | 8.12  | 1.45         | 13869    | 15861                                                                        |
| 5         | 1144M     | Randolph.....  | 2.82                         | 10.45 | 1.00         | 13475    | 15731                                                                        |
| 5         | 1297C     | Randolph.....  | 1.45                         | 10.10 | .98          | 13718    | 15693                                                                        |

TABLE 21  
UNIT COAL VALUES—(Concluded)

| State No.                | Table No. | COUNTY               | ANALYSES OF COAL AS RECEIVED |       |              |          | "Unit Coal" Basis                             |
|--------------------------|-----------|----------------------|------------------------------|-------|--------------|----------|-----------------------------------------------|
|                          |           |                      | Mois-<br>ture                | Ash   | Sul-<br>phur | B. t. u. |                                               |
|                          |           |                      |                              |       |              |          | B. t. u. — 5000 S                             |
|                          |           |                      |                              |       |              |          | 1.00 —                                        |
|                          |           |                      |                              |       |              |          | (1.08 Ash + <sup>22</sup> / <sub>40</sub> S.) |
| WYOMING                  |           |                      |                              |       |              |          |                                               |
| 1                        | 1368M     | Sheridan . . . . .   | 22.00                        | 3.37  | .60          | 9796     | 13192                                         |
|                          | 1479C     | Sheridan . . . . .   | 22.63                        | 4.50  | .59          | 9734     | 13444                                         |
| 2                        | 1376M     | Weston . . . . .     | 8.60                         | 21.90 | 4.94         | 9709     | 14550                                         |
|                          | 1571C     | Weston . . . . .     | 9.44                         | 20.72 | 3.91         | 9650     | 14320                                         |
|                          | 2131C     | Weston . . . . .     | 8.93                         | 20.79 | 4.03         | 10001    | 14757                                         |
| 3                        | 1976M     | Crook . . . . .      | 17.74                        | 11.55 | 7.03         | 9527     | 13918                                         |
|                          | 2278C     | Crook . . . . .      | 15.12                        | 16.70 | 6.66         | 8928     | 13604                                         |
| 4                        | 3160M     | Carbon . . . . .     | 12.32                        | 5.19  | .23          | 11102    | 13534                                         |
|                          | 3363C     | Carbon . . . . .     | 11.30                        | 7.31  | .28          | 10755    | 13316                                         |
|                          | 3396C     | Carbon . . . . .     | 12.40                        | 6.77  | .26          | 10706    | 13341                                         |
| 5                        | 3164M     | Sweetwater . . . . . | 12.41                        | 2.52  | .80          | 11920    | 14071                                         |
|                          | 3213C     | Sweetwater . . . . . | 11.64                        | 3.41  | .81          | 11768    | 13923                                         |
| 6                        | 3202M     | Uinta . . . . .      | 20.57                        | 2.63  | .51          | 10237    | 13383                                         |
|                          | 3390C     | Uinta . . . . .      | 19.00                        | 3.12  | .49          | 10307    | 13293                                         |
| ALASKA                   |           |                      |                              |       |              |          |                                               |
| 2479                     | .....     | .....                | 4.43                         | 4.65  | .51          | 13640    | 15083                                         |
| 2483                     | .....     | .....                | 13.89                        | 7.23  | .82          | 12137    | 15537                                         |
| 2219                     | .....     | .....                | 6.74                         | 12.47 | .44          | 11968    | 15017                                         |
| 2222                     | .....     | .....                | 2.55                         | 6.05  | .57          | 13711    | 15101                                         |
| 2224                     | .....     | .....                | 6.60                         | 10.87 | .41          | 11338    | 13898                                         |
| 2227                     | .....     | .....                | .90                          | 4.90  | .60          | 14868    | 15873                                         |
| ARGENTINA, SOUTH AMERICA |           |                      |                              |       |              |          |                                               |
| 4079C                    | .....     | .....                | 7.67                         | 42.85 | 1.21         | 6320     | 13792                                         |
| BRAZIL, SOUTH AMERICA    |           |                      |                              |       |              |          |                                               |
| 172                      | .....     | Dry Coal . . . . .   | .....                        | 27.54 | 3.02         | 10028    | 14398                                         |
| 173                      | .....     | Dry Coal . . . . .   | .....                        | 27.84 | 4.53         | 9830     | 14241                                         |



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